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Feasibility of Integration of Peanut Based Bio-Diesel into a Mainstream Market

Dustin Hogan

FEASIBILITY OF INTEGRATION OF PEANUT BASED BIO-DIESEL INTO A MAINSTREAM MARKET

by

DUSTIN HOGAN

(Under the Direction of Anoop Desai)

ABSTRACT

There has been increased emphasis on alternate energy sources in recent years. This interest stems from diminishing supplies of fossil fuels combined with an ever-increasing global demand for energy. Biodiesel constitutes one such source of alternate energy. It is a renewable diesel fuel substitute that can be manufactured from a variety of naturally occurring oils and fats. Several methods of production have been tried and successfully implemented to develop biodiesel as a viable energy source. However, this research has been confined primarily within the auspices of a research laboratory. The mass appeal of biodiesel and its viability as a dominant energy source can be established by developing a comprehensive methodology to achieve large-scale transfer of technology from the laboratory to the marketplace. Such a methodology needs to take into account the technological characteristics of the fuel production process, environmental effects of biodiesel emissions, and economic factors integral to the biodiesel supply chain. It is essential to analyze the aforementioned characteristics in order to successfully achieve the cost effective integration of this alternate fuel source into the marketplace. Towards this end, a thorough literature review of the state of the art in biodiesel production techniques and availability characteristics of peanuts as a source has been presented in retrospect to secure the integrity of the research involved. This research as well as related outcomes as a result of widespread integration of biodiesel into a mainstream market has been presented. Similarly, the strategies and effects of the introduction of large-scale usage of bio-fuels have also been targeted.

INDEX WORDS: Renewable energy, Peanut based bio-diesel, Bio-diesel, Clean energy, Renewable integration, Technology transfer

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MAINSTREAM MARKET

by

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DEDICATION

This research involved with this project is dedicated to all the people that have worked hard to formulate ways to make fuel from clean biodegradable materials to help sustain our clean environment that we are ever so blessed to have. The full scale integration of sustainable energy is a necessity to the technological advancement of humankind, and those people involved with making this process a reality deserve all the credit as this process is implemented into our daily lives.

ACKNOWLEDGEMENTS

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Sincerely,
Dustin Hogan

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CHAPTER 1

INTRODUCTION TO BIO-DIESEL RENEWABLE TECHNOLOGIES

1.1 Introduction to Renewable Technologies

There has been significant interest in renewable energy and its applications in recent years. This is primarily attributable to the decreasing supply of fossil fuels as a dominant energy source and the subsequent astronomical rise in fuel prices. Energy is the driving force of human civilization. The exponential rise in productivity and higher standard of living since the industrial revolution has been made possible by incremental innovations in technology. Most of these innovations tend to require abundant amounts of energy. Fossil fuels have traditionally been the principal energy source for the world. They can be classified into three types, based on their physical characteristics. Crude oil, natural gas, and coal constitute the three conventional forms of fossil fuels. Controlled combustion of fossil fuels results in the release of heat. Heat can be further harnessed to provide different forms of energy. Global supply of fossil fuels is limited. There has been growing evidence that points to decreasing supplies of coal as well as crude oil. For instance the peak oil theory propounded in the 1970's predicted that global oil reserves had already reached their maximum capacity and would begin a gradual but definite decline in the years ahead (Tyson, 1997). Similarly of all the coal that has been mined, 80% has been mined in the last 60 years (World Coal Institute). The global demand for energy however has been steadily increasing due to the rising standards of living of peoples across the world. The situation prompts a substantial investment in energy infrastructure in order to fulfill this demand. This not only includes more efficient ways of power generation and distribution but a greater emphasis on tapping non-conventional sources of energy such as solar power, wind power, hydroelectric power, nuclear power, and bio-fuels as well. It needs to be realized that the aforementioned sources of energy have not been exploited to their full potential. For instance wind power constitutes approximately 3% of all power generated in the United States per year (Renewable energy research lab, UMASS, 2008). Potential exists for the mainstream development of alternate energy sources. Their large-scale introduction, integration, and implementation could provide outstanding opportunities for individuals, companies, and organizations. Renewable energies offer several advantages to the consumer. Energy sources such as solar power, wind power, hydroelectric power, and bio-fuels can easily be replaced and remanufactured. They are also a lot more environmentally friendly than fossil fuels. The need to reduce the dependence on fossil fuels has increased dramatically. The necessary technologies and opportunities to significantly reduce the dependence on crude oil and other fossil fuels exist however, they have not been implemented fully (Fripp *et al*, 2004).

Given the myriad sources and opportunities afforded by alternate energy, bio-fuels lend themselves most readily to widespread adoption due to their adaptability to the current state of technology. Bio-fuels are made from plants and animal fat. Plants use photosynthesis to grow and to produce biomass, which is also known as bio-matter and is used to produce bio-fuels. Bio-fuels can be a liquid, solid, or gas. The most common type is liquid bio-fuels, liquid bio-fuels can be comprised of alcohol from fermenting sugars in plants, and this would be a bio-ethanol. Bio-fuels can also be created from vegetable oils, animal fats, and recycled grease composites; this is called bio-diesel. Last year bio-fuels provided almost 2% of the world's transport fuel (Vanudevan, 2008). With the rise in prices of fossil fuels companies are becoming more interested in their biological footprint. Bio-diesel can be readily used to replace and or accompany gasoline as a primary fuel source for internal combustion engines. Bio-diesel has a distinct benefit over most other bio-fuels; it requires little to no conversion for use. Bio-diesel fuels will combust in a standard diesel engine without any modification. It can also be combined with petro-diesel for optimum effects. The reaction with bio-diesel that causes erosion and degradation of rubber lines, seals, and hoses in older cars is the only cause for concern. However, this is easily overcome by replacing these elements with a sustainable material such as fluoroelastomers (FCM), which are nonreactive to bio-diesel (Van Gerpen, 2004). There are also many types of bio-diesel; bio-diesel can be produced from a lot of different types of vegetables oils. The most common bio-diesel is from chemically reacting lipids, such as fatty acids from plants and animal fats.

Given their importance as detailed in the preceding paragraph, this paper explores state of the art research in bio-fuel production, commercialization methodologies, and economical advantages of their large-scale adoption. It is an ongoing topic of research and development that must be sub-divided into many subprojects and research endeavors. This is the first step towards development of a comprehensive methodology that could effectively transfer bio-diesel technology from the laboratory to the market place and it is just as important as the technological development if not more. This methodology could be developed and gauged by the amount of time required for a technology to become marketable as well as its related cost. Also, long-term acceptance by the market and the actual availability to the consumer can be measured as this process develops (Van Gerpen, 2004).

1.2 Bio-diesel Background

Bio-diesel fuels have existed before the first functional diesel engine was invented. In 1853 two scientist, E. Duffy and J. Patrick used transesterification of vegetable oil to create fuel. The first diesel engine ran on its own power in Augsburg, Germany on August 10, 1893. Peanut based biodiesel was the first fuel of its kind to power a diesel engine (Arvizu, 2001). The first spike of bio-diesel usage was during World War II, but little came from this. This was attributable to low gas prices, thus minimizing the need for non-petroleum based fuel. During the energy crisis of the 1970's, significant research pertaining to the use of transesterified oils from different vegetables was performed. This was done in an attempt to find a cost effective method to reduce energy dependence on other countries. Many different methods were invented during this period, some of which are still being researched today. Throughout the 1990's many Europeans pushed for local production of bio-diesel. These included Germany, Sweden, and France. They gradually experimented with blends of mixed bio-diesel with petroleum diesel. Research indicates that in the European Union there are currently twenty-one countries with commercial bio-diesel projects (Foust, 2007). In 2005 Minnesota announced that it would be the first state to follow Europe's trend and mandated that all diesel sold in the state must contain at least 2% bio-diesel (Foust, 2007). With the growing emphasis on clean air as well as reduction of foreign oil dependency, bio-diesel technology has become a lot more conventional in the last few years. As petroleum based fuel prices continue to rise and become more unpredictable, American consumers are becoming more cognizant of advancements in alternative fuel technology. As a result of this new found awareness, the use of hybrid technologies has become more accessible to the consumer. Higher availability of cleaner renewable energy should lead to increased acceptance. The understanding of the opportunities and environmental benefits of bio-diesel and other renewable energies is a great negotiation tool to help the public understand long-term benefits of these technologies. The following section presents the different variations of bio-diesels in terms of their chemical composition. It is vital to understand the background of bio-diesel in terms of its history, economic and environmental benefits as well as different product mix variations in order to fully appreciate the importance of achieving large-scale bio-diesel technology transfer to the market place.

1.3 Variations of Bio-Diesel: Blending and Commercial Exploitation

Bio-diesel can be made from many different kinds of vegetables and animals fats, each having its own properties and individual elements. Most bio-diesels are made from reacting lipids from either vegetable oils or animal fats with alcohol. In the United States bio-diesel is standardized as a mono-alkyl ester. This reaction is constant across most different vegetable oils and fatty acids retained from animal fats. There are various ways to blend and mix bio-diesel with other petroleum based diesels. The blending amount is commonly known as the “B-factor”, fuel that contains 25 percent bio-diesel is known as B-25 and fuel that contains 85 percent bio-diesel is known as B-85. This blending can occur in various ways as presented below (Van Gerpen, 2004):

- In-line mixing
- Mixing in tanks at the manufacturing plant
- Splash mixing
- Mixing at the pump

In order to make the aforementioned technologies commercially available, a method must be found that distinguishes issues that are preventing mass production and consumption. It can be recognized that the first challenge is acceptance within the market. If the technology is not accepted it does not need to be produced. Preparation for conversion is not necessary and neither is any other significant measure to prepare for the change from the current technology. Once the technology is accepted and the consumers develop a demand for the product. It can then become feasible to create a supply to accompany the demand. To do this an adequate amount of testing and development needs to be done in order to ensure the product is safe and serves its purpose without any undesirable effects (Van Gerpen, 2004).

After the need for supply is determined, a cost conscious method of production is needed to make it commercially available at a reasonable cost. The concern with new technologies is that the cost of production and profit margins increase the product far higher than it's worth. Petroleum based fuels have been around for such a long time, its production process has nearly been perfected. The general public is unwilling to change their consumption habits substantially, especially in the face of high cost related to the change. With the unpredictable but constant rise in gas prices, it is inevitable that the price of both fuels will be more comparable as the limitation of natural resources causes the price of fossil fuels to rise until it is cost efficient to use renewable fuels. The support of these methods now can preserve resources and cut cost today and in the future.

Once the technology can be developed within reason it must then be tested for both quality and safety. Numerous trials must be conducted including failure testing, statistical analysis, wear and tolerance analysis, stress analysis, and environmental reactions to the product especially those dealing with fuels that cause emissions of toxic chemicals and particles. Burning of fuel causes indirect and long-term effect on the engine and the environment. These different variables must be manipulated and results analyzed before any type of mass production could begin. Most bio-fuels are very environmentally friendly and release little to no harmful emissions. As for bio-diesel, it lets out far less carbon dioxide but in turn produces 10% more nitrogen oxide than convention diesel. Nitrogen oxide emissions can be reduced with the use of a catalytic converter, thus making it more efficient and more economically viable than petroleum based fuels (Van Gerpen, 2004).

Bio-diesels offer economically and environmentally conscious long-term benefits. Appropriate steps need to be taken to make this technology available to more people so there will be a smaller environmental footprint. The availability and consumption of bio-diesels is on the rise but new age manufacturing and conversion techniques could make this increase at an even faster rate. At $3.08 per gallon bio-diesel is currently 40 cents cheaper than petroleum diesel, with a more efficient production method; this price could see even more price decreases. The following section of this paper will examine the various technologies related to bio-diesel production. It will also present several significant advancements in those technologies.

1.4 Bio-Diesel Technologies

1.4.1 Advancements in Bio-Diesel Technologies

Advancements in bio-diesel technologies are the driving force behind creating a strong market for bio-diesel and other bio-fuels. Creating a manufacturing process that would cut cost by as little as 5 or 10 percent would cause bio-diesel production cost to drop below the cost of petroleum and make it more reasonable for most consumers to choose bio-diesel over petroleum based fuels. Minute changes could have dramatic effects that could help skew prices and production in the right direction.. Bio-fuel sources are more plentiful thus, their prices are more sustainable and predictable (NCEP, 2004).

Bio-diesel has certain effects on engine parts that are of concern to the consumers. Like any other diesel engine, engines that run on bio-diesel are harder to start in cold weather. This can be taken care of by heating the fuel before injecting it into the combustion chamber. Bio-diesel has a lot of its own unique challenges related to testing and usage. Addressing these challenges and gaining more knowledge about bio-diesel and its effect on the engine, manipulating the fuel so that the engine will run smoother and more efficient is a challenge many scientists and developers face. Solutions to these challenges will offer ways to make bio-diesel more dependable and acceptable to the public. Across institutions and government research facilities most of the small issues that plague bio-diesel have been worked out and solved. The development of a universal database to address the various problems encountered during bio-diesel production testing and use could help formulate a fuel-engine combination that would serve as the benchmark for the development of future bio-diesel technologies. Table 1 depicts the known problems, probable cause and potential solutions for using bio-diesel derived from straight vegetable oil.

Table 1: Issues, causes, and solutions of Bio-diesel fuels

Problem	Probable cause	Potential Solution
Short Term		
1. Cold weather starting	High viscosity, low cetane, and flash point of vegetable oils.	Preheat fuel prior to injection. Chemically alter to and ester
2. Plugging and gumming of filters lines and injectors	Natural gums (phosphatides) in vegetable oil.	Partially refine oil to remove gums, filter to 4-microns
3. Engine knocking	Very low cetane of some oils. Improper injection timing.	Adjust injection timing. Use higher compression engines. Preheat fuel prior to injection. Chemically alter fuel to an ester.
Long term		
4. Coking of injectors on piston and head of engine	High viscosity of vegetable oil. Incomplete combustion of fuel. Poor combustion at part load with vegetable oils.	Heat fuel prior to injection. Switch engine to diesel fuel when operations at part load. Chemically alter the vegetable oil to an ester.
5. Carbon deposits on piston and head of engine	High viscosity of vegetable oil. Incomplete combustion of fuel. Poor combustion at part load with vegetable oils.	Heat fuel prior to injection. Switch engine to diesel fuel when operations at part load. Chemically alter the vegetable oil to an ester.
6. Excessive engine wear	High viscosity of vegetable oil. Incomplete combustion of fuel. Poor combustion at part load with vegetable oils. Dilution of engine lubricating oil due to blow-by of engine oil.	Heat fuel prior to injection. Switch engine to diesel fuel when operations at part load. Chemically alter the vegetable oil to an ester. Increase motor oil changes. Motor oil additives to inhibit oxidation.
7. Failure of engine lubrication oil due to polymerization	Collection of polyunsaturated vegetable oil blow-by in crankcase to the point where polymerization occurs.	Heat fuel prior to injection. Switch engine to diesel fuel when operations at part load. Chemically alter the vegetable oil to an ester. Increase motor oil changes. Motor oil additives to inhibit oxidation.

Source: Harwood [1984]

One of the more popular areas for research is the introduction of different materials to make bio-diesels. Bio-diesel can be made from almost twenty-five different types of vegetable oil and animal fat deposits, although considerable debate exist over which methods are the most efficient. One of the most common types of precursors that are used to make bio-diesel is cooking oil. Cooking oil can be reused and refined to make bio-diesel. There is still a lot of confusion and controversy surrounding the differences between reused cooking oil and pure vegetable oil grown specifically for fuel, SVO (Straight Vegetable Oil). Reused cooking oil goes through a process of cleaning, transesterification, and refining. This shortens the lipid chains, before it is used as fuel. However, once processed, certain diesel engines can run on 100 percent blends of this bio-diesel with no engine adjustments or mixes with mineral diesel needed (Van Gerpen, 2004). One of the benefits of using bio-diesel made from used vegetable oil is in utilizing a waste product, which until recently has been poured down drains or sent to a landfill. According to research by the BBC, the catering industry in the UK produces about 50-90 million liters of waste cooking oil each year, while Ireland discards more than 10,000 tons of waste vegetable oil annually (Van Gerpen, 2004).

Although this sounds like a huge amount of oil, there is simply not enough cooking oil in the UK to entirely replace diesel as a fuel source. This estimate is based on a report by the Government's Better Regulation Commission. Current waste oil supplies could only feasibly power around one out of every three hundred fifty of the UK's cars. In fact, the Energy Systems Research Unit estimates that the UK can only produce enough bio-diesel from waste vegetable oil to displace less than 0.6 percent of conventional diesel engines (Patel et al, 2003).

The scenario presented in the preceding paragraph hinders the possible use of recycled bio-fuels. As a result, recycled oils may not attract the attention as a valuable source of energy. In reality, this energy can be obtained, processed and used locally, which could still play a useful part in reducing the large contribution that road transport makes to carbon dioxide emissions. SVO's on the other hand include any and all oils from plants that have been specifically grown for their use as a fuel. The most commonly known of these are rapeseed and palm oil. The two major problems with these oils is their displacement of food crops and the destruction of habitat as land is cleared for production.

1.4.2 Second Generation Bio-fuels

Other bio-fuels that are termed second-generation bio-fuels are also a productive opportunity for clean energy. Second generation bio-fuels are bio-fuels that are derived from lignocellulosic crops. Plants are made from lignin and cellulose, second generation bio-fuels extract these two components and split them. After this process the cellulose is fermented into alcohol in much the same way as first generation bio-fuels. These second generation bio-fuels are environmentally friendly as well.

Second generation bio-fuel technologies have been developed because first generation bio-fuels manufacturing have important limitations. First generation bio-fuel processes are useful, but limited: there is a threshold above which they cannot produce enough bio-fuel without threatening food supplies and biodiversity. They are not cost competitive with existing fossil fuels such as oil, and some of them produce only limited greenhouse gas emissions savings. Second generation bio-fuels can help solve these problems and can supply a larger proportion of fuel supply sustainably, affordably, and with greater environmental benefits (Grant, 2009).

Second-generation bio-fuels include cellulosic ethanol, which is made from plant waste such as wood chips or straw. Such products are currently considered less controversial than first-generation ones, which have been linked to food price inflation, deforestation and a questionable performance in terms of reducing carbon emissions (Mosier *et al*, 2003).

CHAPTER 2

ECONOMIC EFFECTS OF BIO-DIESEL

2.1 Impact of Energy on the Economy

Energy is an important component in the global economy, and 90% of the commercially produced energy can be traced to fossil fuels such as crude oil, coal, and gas, which are non-renewable in nature (Sourie *et al*, 2006). Much of the energy supply in the world comes from politically volatile regions of the world. In order to enhance energy security, many countries, including the US, have been emphasizing production and use of renewable energy sources such as bio-fuels, which is emerging as a growth industry in the current economic environment. This section of the paper sheds light on the drivers of the current bio-fuel boom as well as its impacts on agricultural markets (Birur *et al*, 2007).

Energy consumption and modes of energy production have a direct as well as an indirect effect on the economy. Everything consumed must be transported from some remote location. If the cost of gas is low, then it costs less to transport these materials, resulting in a lower cost for the consumer. Lower fuel cost on the other hand translates into substantially lower prices down the supply chain. This is attributable primarily to lower transportation costs. If the price of gas rises, then so does the price of all transported goods. It can thus be appreciated that gas prices and consequently energy prices constitute a major force in driving the economy as depicted in Figure 2. Development of a fuel with reliable and predictable supply characteristics would result in a more predictable economy. The current petroleum prices are very unpredictable and unstable as depicted in Figure 1.

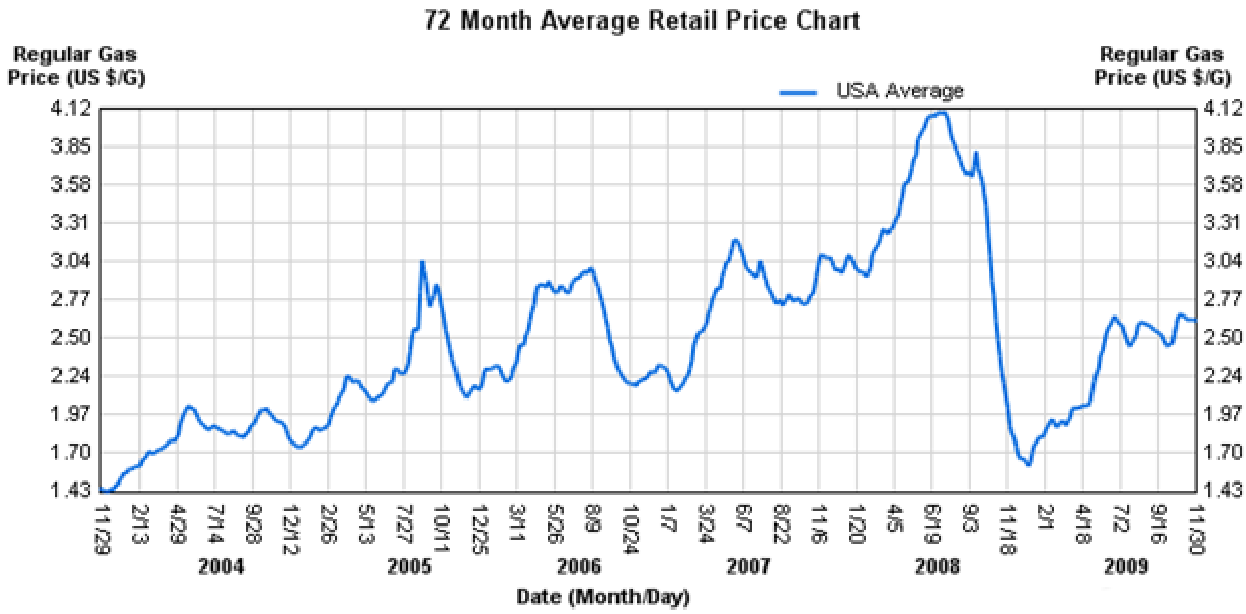

Figure 1: 6 year chart showing the upward rise in petroleum gasoline prices.

Source: Gas buddy [2009]

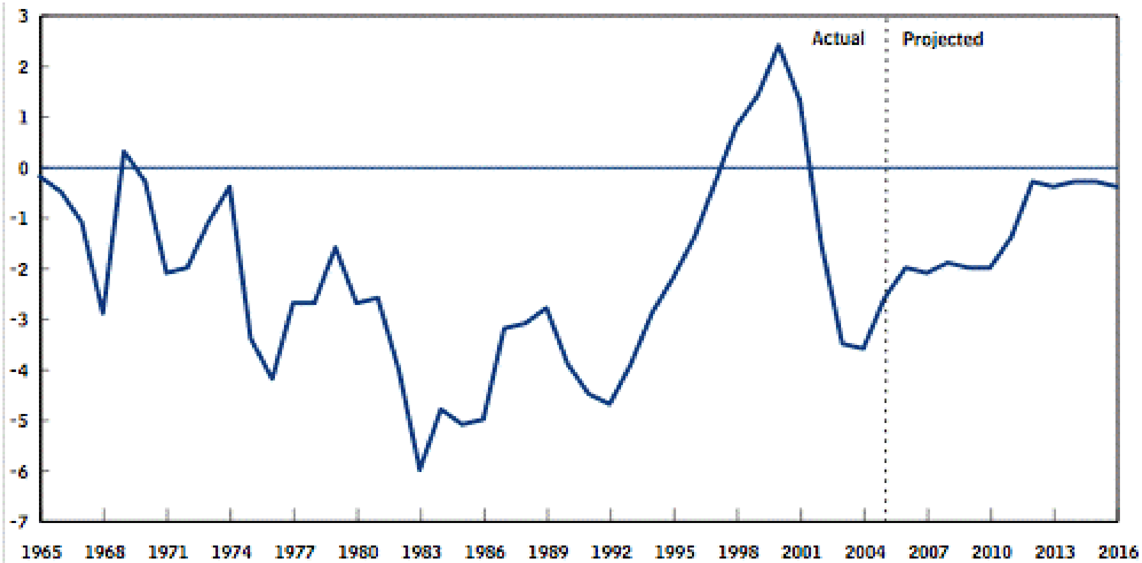

Figure 2: GDP of the American economy over the last forty years

Source: BEA [2010]

2.2 Economic Effects of Bio-diesel Integration

The introduction of bio-diesel could stimulate the economy while at the same time offer reduced dependence on a diminishing energy source (fossil fuels). As the interest grows in the product it will start to become accepted more and more and rise exponentially until it has a majority market share. The inevitable fluctuation of gas price is something that cannot be controlled. If bio-diesel were introduced into the mainstream market, dependence on foreign countries would diminish.

Bio-fuels could serve as a means to reinvigorate the flaccid US economy over the next few years, according to a new report focused on the economics of biotechnology (Grant, 2009). Conversion to bio-fuels could result in the following advantages:

- Direct job creation from advanced bio-fuels production could reach 29,000 by 2012, 94,000 by 2016, and 190,000 by 2022.

- Total job creation, accounting for economic multiplier effects, could reach 123,000 in 2012, 383,000 in 2016, and 807,000 by 2022.

- Direct economic output from the advanced bio-fuels industry is estimated to rise to $5.5 billion in 2012, $17.4 billion in 2016, and $37 billion by 2022.

- Taking into consideration the indirect and induced economic effects, the total economic output effect for the U.S. economy is estimated to be $20.2 billion in 2012, $64.2 billion in 2016, and $148.7 billion in 2022.

- Advanced bio-fuels production under the renewable fuel standards (RFS) could reduce U.S. petroleum imports by approximately $5.5 billion in 2012, $23 billion in 2016, and nearly $70 billion by 2022.

- The cumulative total of avoided petroleum imports over the period 2010–2022 would exceed $350 billion (Grant, 2009).

"Increasing advanced bio-fuel production to a modest target of 45 billion gallons by 2030, which can be achieved by maintaining the same pace of technology development, could create more than 400,000 jobs within the industry and 1.9 million new jobs throughout the economy. Further, it could provide an economic boost of $300 billion. Continued federal support can help the industry quicken the development of the necessary technology and weather the risk of oil price volatility." (Bio-era, 2009)

CHAPTER 3:

ENVIRONMENTAL EFFECTS OF BIO-DIESEL

3.1 Impact of Energy Consumption on the Environment

Exhaust from conventional fueled diesel vehicles contains numerous known and suspected human carcinogens. Diesel exhaust was recently classified as a Toxic Air Contaminant by the California Air Resources Board (Van Gerpen, 2004); was the subject of an EPA health risk assessment (EPA, 2010), and a critical review by the Health Effects Institute (1995), which is sponsoring on-going work in this area. One of the potential benefits of biodiesel fuel use is a decrease in the overall toxicity of emissions. This is a result of the elimination or reduction of certain toxic components of diesel exhaust, which are present in conventional fuels but not in biodiesel. Additional benefits may be associated with potential reductions in the total mass of particulate matter in the exhaust.

3.2 Carbon Intensity of Bio-Diesels Compared to Fossil Fuels

Bio-diesel has been shown to have multiple benefits to the environment when it is compared to petroleum-based fuels. Particulate emissions are reduced by around 50 percent compared with fossil-sourced diesel. Also carbon intensity of bio-diesels is sufficiently less than that of petro-diesels (Lindhjem *et al*, 2003). Figure 3 presents the carbon dioxide emissions associated with various types of bio-fuels.

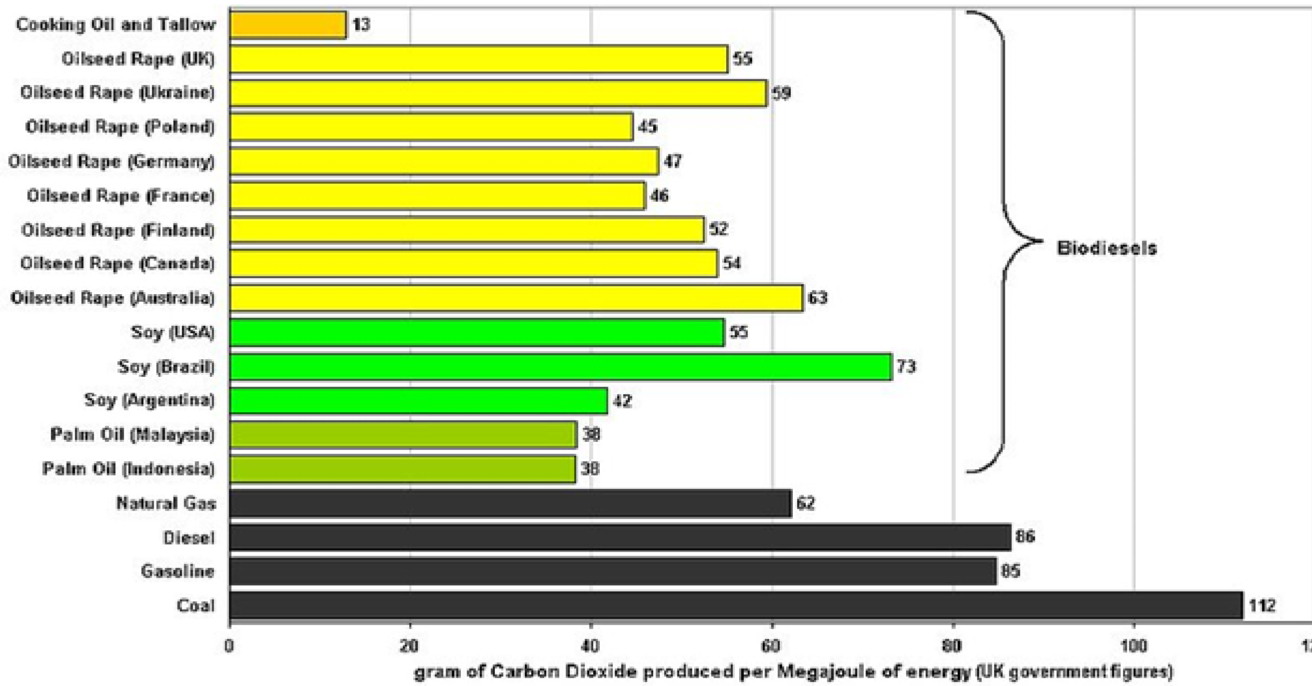

Figure 3: Carbon Intensity of Bio-diesels and fossil fuels that are burnt sorted by country of origin.

Source: EPA [2010]

Scientific research confirms that bio-diesel exhaust is less harmful to humans than diesel fuel exhaust because it lacks aromatic compounds. The purer the bio-diesel fuel is, the less likely it is to create cancer causing compounds such as, polycyclic aromatic hydrocarbons. Most of the poisonous compounds common to diesel exhaust are reduced by 75 to 85 percent by using bio-diesel fuel (Lindhjem *et al*, 2003). Bio-diesel is also easier on the lungs because it reduces the emission of particulate matter that causes asthma and other lung disorders by about forty-seven percent. Burning just a 2% bio-diesel blend in on-road vehicle that usually takes diesel fuel will curtail harmful emissions. Annually this one action has the potential to reduce poisonous carbon monoxide emissions by more than 35 million pounds, reduce ozone forming hydrocarbon emissions by almost 4 million pounds, reduce hazardous diesel particulate emissions by almost 3 million pounds and reduce acid rain-causing sulfur dioxide emissions by more than 3 million pounds (Lindhjem *et al*, 2003). It is obvious that increased bio-diesel use would result in a cleaner environment. Emission of harmful chemicals into the atmosphere such as hydro-carbons, carbon monoxide and other harmful chemicals and particle matter from burning biodiesel are significantly less than those of petroleum based diesel emissions. The only toxin more harmful than petroleum diesel in bio-diesel emissions is nitrous oxide. Figure 4 presents the average emission impacts of bio-diesel for heavy-duty highway engines. It will be appreciated that emissions in the form of particulate matter (PM), carbon monoxide (CO), etc. are reduced substantially as the amount of bio-diesel in any fuel combination approaches 100 %. It will also be noticed that the only noteworthy change in emissions results with a small increase in nitrogen oxide (NOX) concentration.

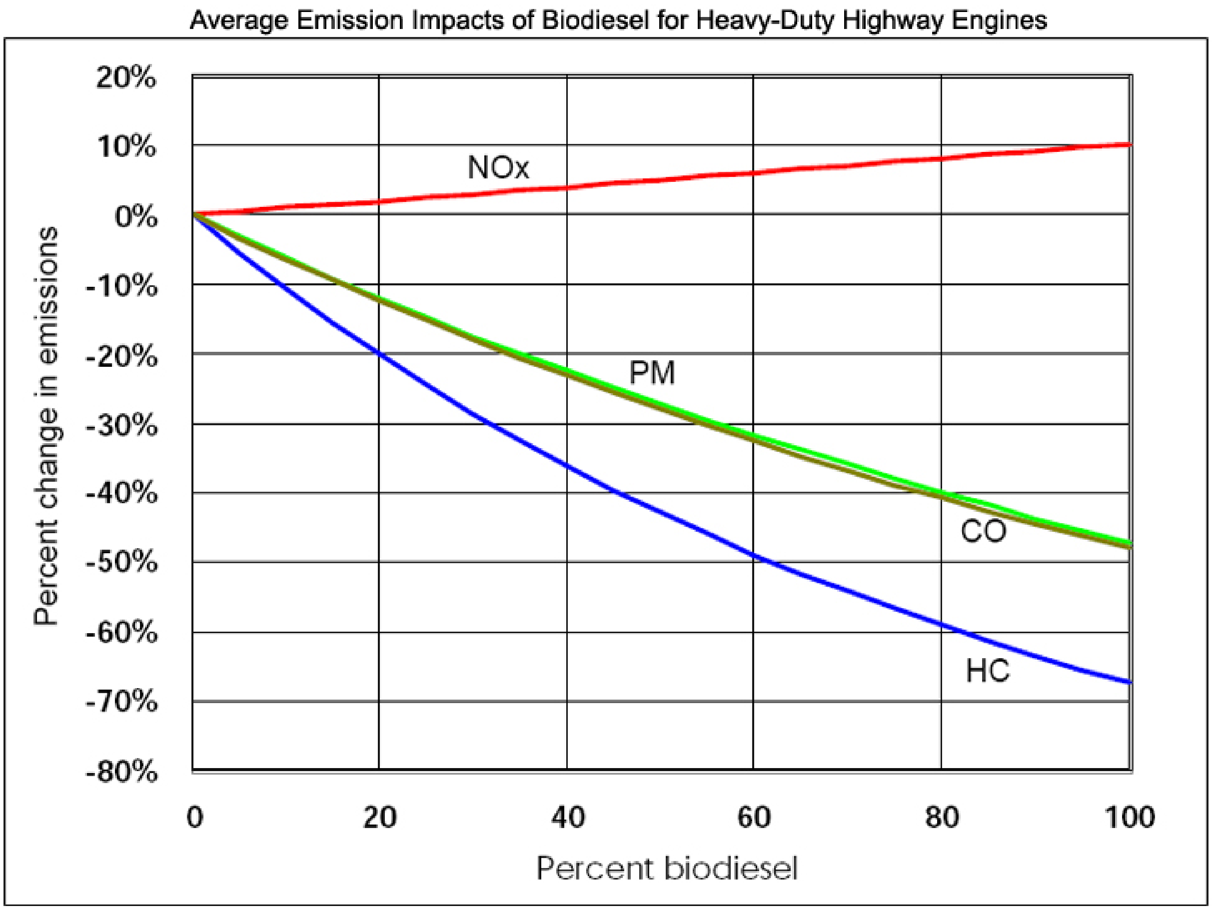

Figure 4: Percent change in emissions as bio-diesel is added until it is completly100% bio-diesel.

Source: EPA [2010]

NOX-Nitrous Oxide

PM-Particulate Matter

CO-Carbon Monoxide

HC-Hydro-Carbon

CHAPTER 4

REASONS FOR INTEGRATION

The following section describes the rationale for bio-diesel integration and how these concepts contribute to the economy, environment, and everyday human life present and future. The advancement of human civilization depends on the development technology. Having a stable power source that can manage the increasing need for more energy is a root issue in developing such technology based infrastructure. The following conditions are factors that contribute to the overall need for an alternative energy source that could replace fossil fuels.

4.1 Increases in Gas Prices

The evident fluctuation in gas prices as shown in Figure 1 creates an unstable economy because of the evident correlation in general market prices and gas prices. As prices increasingly fluctuate they affect the cost of transport and the consumptions of good and service by consumers. As oil prices increase as it distributes throughout the entire economy. When there are large reserves and an increase of active drills in respect to oil, the economy temporarily improves. This is because prices for such things like gas and oil fall and people are able to consume more gas at a lower price. There is more supply and prices fall, therefore people save money on gas and can consume other items in the economy. People working in these industries have more job openings and more jobs filled, therefore creating a lower unemployment rate and a higher national per capita income. This process just explains how fuel prices as product not as an attributable factor that affects the wellness of our economy. Eventually the evident rise in fossil fuels prices will reach a point where most any alternative fuel source will be cheaper and more feasible due to its diminishing supply. That is why it is important to develop a methodology of dependence before it is the only choice.

4.2 Economic Effects of Energy

The evident direct effect of the primary fuel source shows an immense significance to the well being of the economy, but the indirect effects are even more significant. For example, as depicted in Table 2 if the cost of bread to the consumer is $1.00.

- Total cost of production for this loaf of bread $0.60
- transportation cost $0.07 per loaf
- stocking fee $0.02 per loaf
- miscellaneous $0.01 per loaf

Thus the dealer cost for a loaf of bread to $0.70 per loaf. For each loaf the consumer buys the retailer makes 30% profit before the average damaged good is calculated, thus brings us to 25% profit per loaf. Referring to Figure 1 the fluctuation in gas prices on November 19, 2009 where gas prices were $1.43 to June 29, 2008 when the price of gas per gallon had increased to $4.12 which is a 188% increase in price. Applying that to the theoretic bread scenario, it would push the cost of transport to $0.20. The difference of $0.13 per loaf is 50% of the retailer's profit, so an apparent price adjustment would have to be made.

Table 2: Fuels prices in relation to production cost and profit.

Price of Gas	$ 1.43	$ 4.12
Production	$ 0.60	$ 0.60
Transportation	$ 0.07	$ 0.20
Stocking Fee	$ 0.02	$ 0.02
Miscellaneous	$ 0.01	$ 0.01
Total Cost	$ 0.70	$ 0.83
Retail	$ 1.00	$ 1.00
Profit	$ 0.30	$ 0.17

This scenario has the same effect on all consumed products. In reality they may not be as dramatic. This creates the inverse of the aforementioned scenario such that, people are able to consume fewer products at a higher price. There is less supply and prices rise even more, people spend more money on gas and can't consume other items in the economy as easily. People working in these industries have less employment opportunities, therefore creating a higher unemployment rate and a lower national per capita income.

The reliance on such an oscillating market is bound for disaster and detrimental situations that are unavoidable. The integration of such a product that would offer a sustainable and reliant price point could open doors to a more grounded and sustainable economy. Bio-diesel offers the solid infrastructure that could make this process a reality. The cost of transportation is lower because it can be grown locally and produced by such a wide variety of goods. The opportunity to create a localized market based on the local energy consumption could stimulate the area's economy. Lastly with such a wide variety of sources for bio-fuel, it offer a rich yield that can be converted to energy. With such positive resulting factors involving the integration of bio-fuels versus the apparent economic unstable position of fossil fuels, it is evident that bio-fuels are the best choice to power our growing economy.

4.3 Environmental Effects

Fossil fuels have detrimental effects to the environment from its extraction all the way to its admittance into the atmosphere. The effects of these harmful toxins are often very indirect, unnoticeable and sometimes long-term and irreversible. These toxins can cause damage to land from coal mining and damage to miners from black lung disease; environmental degradation caused by global warming, acid rain, and water pollution; and national security costs, such as protecting foreign sources of oil. Many of the environmental problems our country faces today result from our fossil fuel dependence.

4.3.1 Thermal, Air, Water, and Land Pollution

Production, transportation, and use of oil can cause water pollution. Oil spills, for example, leave waterways and their surrounding shores uninhabitable for some time. Such spills often result in the loss of plant and animal life. Coal contains pyrite, a sulfur compound; as water washes through mines, this compound forms a dilute acid, which is then washed into nearby rivers and streams. Fossil fuels also contaminate the air and water too. Several important pollutants are produced by fossil fuel combustion: carbon monoxide, nitrogen oxides, sulfur oxides, and hydrocarbons. During the process of generating electricity, fossil fuels produce heat energy, since the process is inefficient, much of the heat is released to the atmosphere or to water that is used as a coolant. The heated water is returned to rivers or lakes can upset the aquatic ecosystem.

4.3.2 Global Climate Change

Global climate change is the increase of global temperature caused by the impacts of human civilization (Figure 5). It is often a topic that is debatable among different people but the facts show that greenhouse gases are slowly accumulating causing the greenhouse effect. This happens when “greenhouse gases” prevent the release of heat from the earth’s atmosphere. The concept is simple just like a greenhouse allows heat to enter but prevents most of it from exiting. The greenhouse gasses act as the greenhouse and trap the suns heat and radiation within our atmosphere. Greenhouse gasses absorb the radiation from the sun and hold the heat in the atmosphere and cause the air temperature to increase. This process can lead to global warming, which could trigger many different negative environmental effects that could have destructive reactions to our planet. By their percentage contribution to the greenhouse effect on Earth the four major gases are:

- water vapor, 36–70%
- carbon dioxide, 9–26%
- methane, 4–9%
- ozone, 3–7%

The increase of the greenhouse effect through human activities is known as the anthropogenic effect. This increase greenhouse gasses from human activity is attributable mainly to increased atmospheric carbon dioxide levels. Carbon dioxide is produced by fossil fuel burning and other activities such as cement production and tropical deforestation. As we industrialize more and do not take this pollution into account it will only get worse. Our atmosphere will continue to become polluted and the effects of global warming will continue to increase.

This concept has been questioned since the idea was presented because of the pure mass of the atmosphere and how unlikely that humans could produce enough pollution to alter the effects of how the atmosphere works. Although the facts show otherwise, countless evidence shows that humans produce excessive amounts of CO_2 to an extent that would increase the greenhouse effect. Measurements of CO_2 from the Mauna Loa observatory show that concentrations have increased from about 313 parts per million (ppm) in 1960 to about 389 ppm in 2010. The current observed amount of CO_2 exceeds the geological record maxima of about 300 ppm from ice core data. So given the inexcusable evidence it would be implausible to state that the effects of pollution are not contributable to global warming due to greenhouse gasses absorbing and not releasing heat and radiation. The figure depicted below shows the evident rise in the global temperature as the rise of industrial manufacturing and dependence on automotive transportation has increased over the last 80 years.

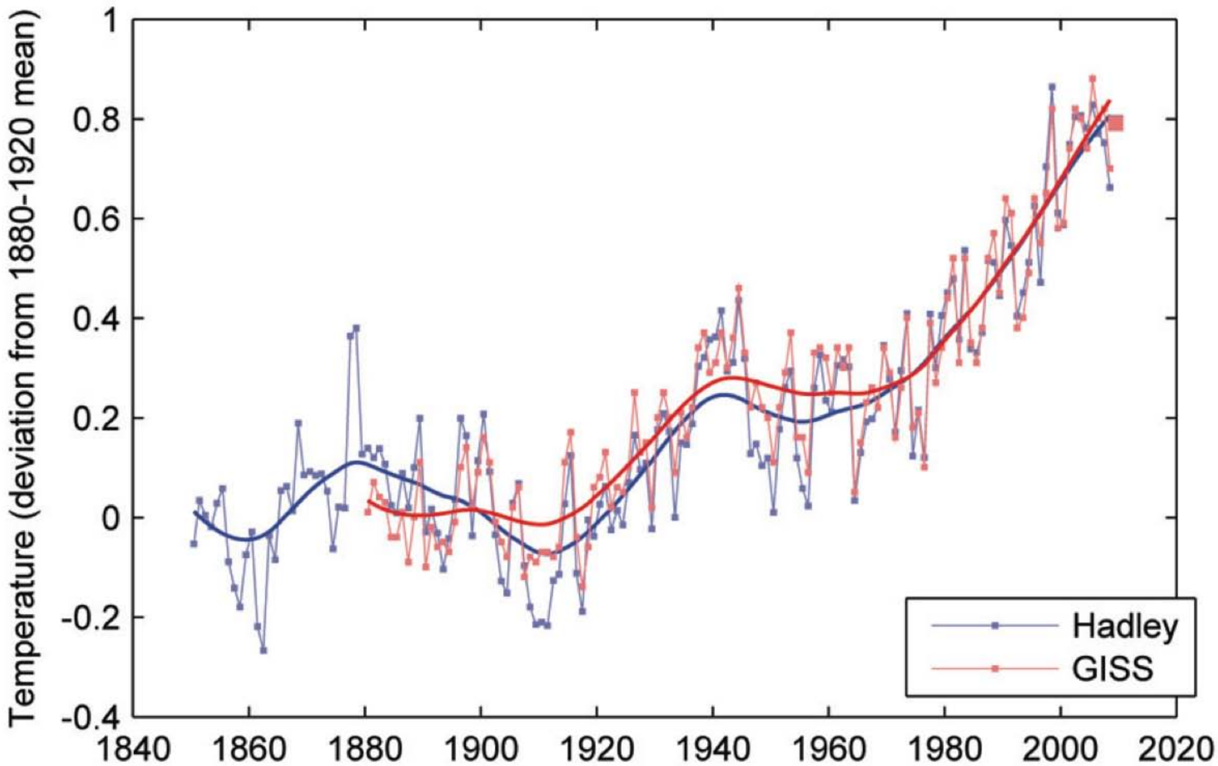

Figure 5: Global temperature as the rise ranging from 1840 to 2009

Source: Rhodes, [2009]

4.4 Reduce Dependence on Foreign Countries

The United States imports over 30% of all its energy sources according to the US Department of Energy (DOE, 2010). Fossil fuels are a large part of the United States economy and one third of it is dependent on other countries. The DOE also states that 38% of fossil fuels are imported while 62% are produced domestically. Twenty years ago, America imported about 21% of all its fossil fuels and imports amounted to only a little over 10% forty years ago (Downs, 2008).

4.5 Creation of Jobs

The integration of bio-diesel as a main source of fuel would require a completely new or completely revamped infrastructure for production, distribution, and use to meet the demand required to make integration successful. The development of this system would need human resources and the goods to keep production intact. This system would offer opportunities for all types of jobs and careers. Like the economic effects of such integration it has indirect effects, which creates opportunities for other markets to obtain the benefits of the introduction of such market. The creation of jobs and the need for more resources would allow for abundant growth and expansion. Also a utilization of new technologies increases so does the development of alternative and supplemental usages, which in turn creates an even more expanded market and even more jobs.

4.6 Market Expansion

The creation of such a broad an unselective market has unlimited room for growth. The realm of expansion for the bio-fuel market is nearly infinite. Research in new technologies offers opportunities for massive expansion as the limits of biologically engineered materials open new gateways to what can be done with organic material. Expansion in the growth and production of bio-fuels offer ergonomically, production, and even agricultural opportunities for market expansion. The creation of such grand infrastructure will need the production of the goods and services required to make it possible. Bio-diesel does not only offer job opportunities in these locations but it also helps sustain the local work force due to the ease of access of the raw materials required for production. As opportunities become available they only create more pathways to other opportunities of expansion.

4.7 Eventual Cost of Fossil Fuels

Fossil fuels are non-renewable, meaning that no matter how limited and conservative with our resources we are, eventually we will run out. This means that as that supply diminishes the cost will rise and so will the price. Fossil fuels only have one direction with price, which is up. Fossil fuels will have to be replaced, the sooner it occurs, the cheaper and also the better it will affect our environment and economy. The expansion of renewable energy has no comparison to the dead endings of fossil fuels.

CHAPTER 5

EFFECTS OF BIO-DIESEL INTEGRATION

5.1 Negative Effects of Bio-diesel Integration

The following section will take into account the negative associated effects of integrating bio-diesel and how these effects can be altered or avoided to help make the integration more beneficial.

5.1.1 Decrease Food Supply

Increasing the demand for bio-based fuels would also require an increased demand on the bio-based product, primarily the food stock. The food stock that we rely on, while abundant, could not stand the sudden increase of demand. Using portions of our food supply would to accompany our need for energy require a new system that would determine and distinguish the need for human consumption versus the need for energy production.

5.1.2 Conversion Cost

Making bio-diesels commercially available to the common consumer will require conversion of the market, the production infrastructure, the products, and even the way in which it is distributed. These conversions will be very costly and are currently less monetarily beneficial than the current product available. Given this, powerful sources needed for contribution to the advancement from most all area are less likely to respond to the need to help push the advancement of making bio-diesel more marketable.

5.1.3 Building a Production Infrastructure

If bio-diesel were to become a major power source to drive our nations need for energy there would need to be an efficient production infrastructure to support the demand of the increased market. To build a production infrastructure of this magnitude would require a cost efficient but still productive mode of manufacturing bio-diesel. The creation of this infrastructure would require new procedures from most all aspects of the production chain.

5.1.4 Accessibility of Bio-diesel to Consumer

The industry for bio-fuels is currently dominated by petroleum based fuels and they are the predominate source by nearly all consumers. If an integration of bio-diesel occurred it would be a struggle to make the product accessible to a wide enough variety of the market to compete with petroleum fuels. A lot of smaller businesses could not afford to convert over to bio-diesel friendly systems and also some consumers would not be willing to conform to the new change.

5.1.5 Price Point of Bio-diesel Final Cost

Bio-diesels are in a development states which means that there are not as many well developed production procedure that can make the price of bio-diesel's price point dip below that of petro-based fuels. Petro-based fuels are the industry standard and their production process have been updated and improved on as technology has grown. This has allowed petro-fuels as a product to move with the technology, making it easier and more efficient to produce. Bio-diesels have not had this opportunity to grow because the small amount of emphasis over the years. This makes bio-diesels less efficient to produce and results in higher prices.

5.2 Mutual Effects of Bio-diesel Integration

The following effects are contributing and reactive factors that have both positive and negative effects on the possible integration of bio-diesel into a mainstream market. These factors may be quite beneficial but still have indirect drawback on certain areas or regions of the integration.

5.2.1 Economic

The economic effect of bio-diesel can be very beneficial to our economy because it opens the market to the many different sources of products that can be used to make bio-diesels. Also with a new market comes new jobs', having bio-diesel as a primary energy source would create abundant amount of jobs. Jobs would be created on many different levels, including production of bio-diesels, manufacturing of bio-diesel products, an increase in studies of the potential opportunities available from bio-products, etc. While bio-diesel integration could bring positive impact to the economy it could also bring negative impacts as well. If bio-diesel replace the industry of petroleum based fuels it would take away a large part of our economy that is spawned by the production, utilization, and advancement of our current energy source. Bio-diesel could not immediately replace the infrastructure that petroleum based fuels built. Millions of jobs rely on petroleum based fuels. Integration of bio-diesel's would need to be carefully assessed to assure utilization of proper resource such that jobs, production methods, and educational programs are not negatively affected and appropriate decisions are made to use this product to stimulate our economy in the most efficient way possible.

5.2.2 Environmental

The production of fuels will have some sort of direct or indirect effect on the environment. To create energy you must use energy. Using nature's energy effects the environment and alters the way biological substances interact with each other. Fossil fuels have been physically, chemically, and biologically changing our environment since their utilization. These destructive forces have been altering our living spaces and harming our resources for years at the cost of our comfort. Creating and proper utilization of a fuel that could limit the amount of harm created by energy consumption would offer a distinct benefit to the future of our planet. Bio-diesels emit far less harmful carbon particles that are negatively affecting our atmosphere and harming our ozone layer. Although taking into account the total life cycle of bio-diesel it shows that many other direct or indirect factors can limit its positive environmental impact. Bio-diesel must be produced from the land, thus utilizing farm land, farm equipment, transportation, and production energy from a manufacturing plant. These production steps require a lot of resources and energy to produce. Also the secondary effects of utilization of these resources can be harmful to various different area of the environment. A method of integration must be considered where proper utilization techniques create a bridge to mend the area where this impact could be detrimental to the environment.

5.2.3 Emissions

The emissions of particulate matter and harmful gases that pollute the atmosphere has been and expediently increasing issue that can be traced to the increased utilization and usage of energy. The pollutant particles that are associated with fossil fuels have damaged our atmosphere over the past century and affected the earth's ozone layer to an extent that to cause climate change. The integration of a bio-based fuel would help reduce the carbon admittance and help preserve our air quality and the planet's climate. Bio-diesel however does emit more nitrogen than fossil fuels. Table 3 shows the different emissions changes as bio-diesel is integrated.

Table 3: Changes of different emission types as the amount of bio-diesel changes.

Emission Changes with Biodiesel Fuels		
Emission	100% Biodiesel*	20% Biodiesel Blend*
Carbon Monoxide	-43.20%	-12.60%
Hydrocarbons	-56.30%	-11%
Particulates	-55.40%	-18%
Nitrogen Oxides	5.80%	1.20%
Air Toxics	-60% to -90%	-12% to -20%
Mutagenicity	-80% to 90%	-20%
Carbon Dioxide**	-78.30%	-15.70%
* Average of data from 14 EPA FTP Heavy duty test cycle tests, variety of stock engines		
** Life Cycle Emission		

Source: [Shumaker, 2003]

5.3 Positive Effects of Bio-diesel Integration

The following effects are associated with the positive outcomes of bio-diesel integration. These factors support the definite need for a source of renewable energy. It is important to understand that these factors are often still in developmental stages and still have lots of room for advancement.

5.3.1 Replaces Petroleum Fuels

The evident issues surrounding usage of petroleum fuels presents logical reasoning for replacing fossil fuels with a more sustainable and renewable source. Bio-fuels offer the opportunities needed to turn this projected reasoning into a reality. Bio-fuels present a competitive but still compatible structure both economically and biologically that could take the place of fossil fuels. The benefits presented throughout this paper show that such integration create opportunities while moving forward with technologies that can sustain our present and future need for energy.

5.3.2 Runs Cleaner than Petroleum Based Fuels

As proposed in the earlier passage, bio-diesel emits less greenhouse gasses and offers a better alternative to the current petroleum fuel admittance of environmentally damaging particulates. The average properly composed bio-diesel burns up to 75% cleaner than the base petroleum diesel fuel. It reduces unburned hydrocarbons (93% less), carbon monoxide (50% less) and particulate matter (30% less) in exhaust fumes, as well as cancer-causing PAH (80% less) and nitrated PAH compounds (90% less) (US EPA, 2010). The ozone-forming potential of biodiesel emissions is nearly 50% less than petro-diesel emissions and contains no sulfur emissions since it is sulfur free. Biodiesel is also a much better lubricant than petro-diesel and extends engine life. A small amount of biodiesel means cleaner emissions and better engine lubrication: 1% biodiesel added to petro-diesel will increase lubricity by 65%. Given its greater oxygen content biodiesel has a higher cetane number than petroleum diesel. The higher the cetane number the more efficient the fuel, the engine starts more easily, runs better and burns cleaner (Addison, 2009).

5.3.3 Less Dependence on Foreign Countries

The United States imports nearly 10 million barrels of petroleum per day (EIA, 2010). This is over half of the total consumption of the country. Given the massive economic effects of petroleum based energy as stated above, the creation of domestically based energy source would create a more stable and less dependent market.

5.3.4 More Competitive Open Market

The ease of availability of the common raw materials creates an influx of the products affected by the introduction of peanut based bio-diesel. This will help utilize waste from over production and create a more broad market that has multiple purposes for its products. This market expansion would allow a market oriented economy for the product, which would be accessible to more competitors and would disable the current monopolistic market base that fossil fuels offer. This gives the consumers options and allows the merchants and producers more freedom in pricing from the beginning of the production process to the end. Implementing this type of market allows sustainability from each products market base to the other since they complement each other. As the opportunities grow with each production process, they begin to attract more competition as other producers become interested. With this newly appointed competition producers become more efficient and try to outdo one another to lower their price in an attempt to grasp the consumer's attention. This will seemingly lower the price of the final product making the product more attractive to the customer.

5.3.5 Abundant Source of Energy

The rationale of moving away from fossil fuels is due to their diminishing supply and delayed capability to be replaced. The idea of an energy source that can be harvested and remanufactured offers substantial opportunities to expand our resources and reside our fears of running out of energy. The natural structure of the peanuts and other renewable sources allow for a nearly unlimited raw material production such that the supply of the product is based on production rather that extraction or availability of the resource. This offers market sustainability and a strong support and belief in the products stability from the consumers. This stability will not only help the product but also all the products that its production makes an impression on. This process is similar to a ripple effect of a rock thrown into a lake. The products that are more directly related to the bio-diesel will have greater benefits and it will decrease as the relation expands outward like a ripple.

CHAPTER 6

DEVELOPMENT OF A METHOD TO INTEGRATE PEANUT BASED BIO-DIESEL INTO THE MARKET REGION OF SOUTH EASTERN GEORGIA (THESIS RESEARCH)

6.1 Introduction to Integration Processes and Benefits

As the inevitable integration of renewable energies proceeds, obstacles that prevent the process needed make the integration more profitable and logical become more apparent. As we advance our resources and efficiency, the anticipated exchange to a more sustainable resource will increasingly present its importance in this process. The evaluation of these obstacles preventing such integration would be necessary to create a process to seamlessly relate these processes an efficient and logical plan of action. The margin of advancement could be an end product of the utilization of resources based on the process development involved with making them most efficient in the large scale production process. The selection of methods and timing of these processes could also determine its outcome. The obstacles and variables associated with this include:

- Economical Effects and Acceptance
- Environmental Effects and Acceptance
- Development of a Manufacturing Process that is both Profitable and Logical
- Current Market's Acceptance to the Product
- Conversion Cost of the Implementation to both the Consumer and Customer
- Affects to Food Supply
- Competing Green Technologies
- Evolution of the Technology
- Cost versus Petroleum Based Fuels

These variables have various effects on the process and certain improvements to adjust for one could either positively or negatively affect at least one other variable. The selection process should rationally develop each area such that the benefits either facilitate or cause as little negative effect as possible on the other variables.

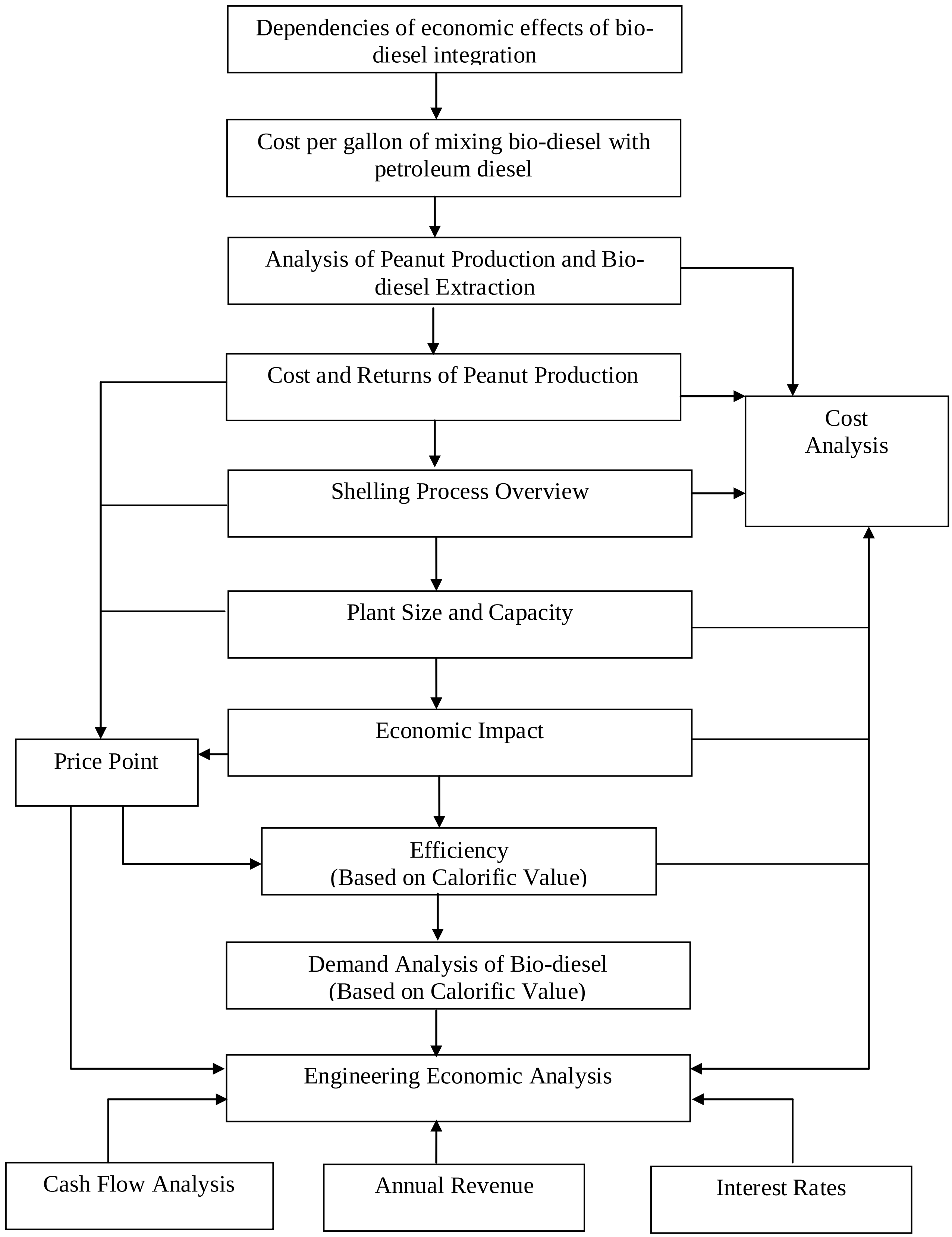

Figure 6: Flow of Process Involved with Biodiesel Integration

6.2 Economic Effects of Bio-diesel Integration

The economical feasibility of this integration process is possibly one of the most important obstacles to surpass. The planning and development of such integration would need to take into account the costs and effects of introducing and increasing bio-diesel's market competence. Variables in this process include but are not limited to:

- Production cause and effects
- Consumer acceptance
- Conversion cost
- Effects to other markets
- Products life span
- Cost of competing products

As with the entire integration process these variables also must be properly weighed and evaluated such that their effectiveness is maximized. Figure 6 depicts the flow of these processes and their dependencies on one another. As expected consumer acceptance is a function of the overall success of most of the other processes since increasing efficiency and quality will increase acceptance.

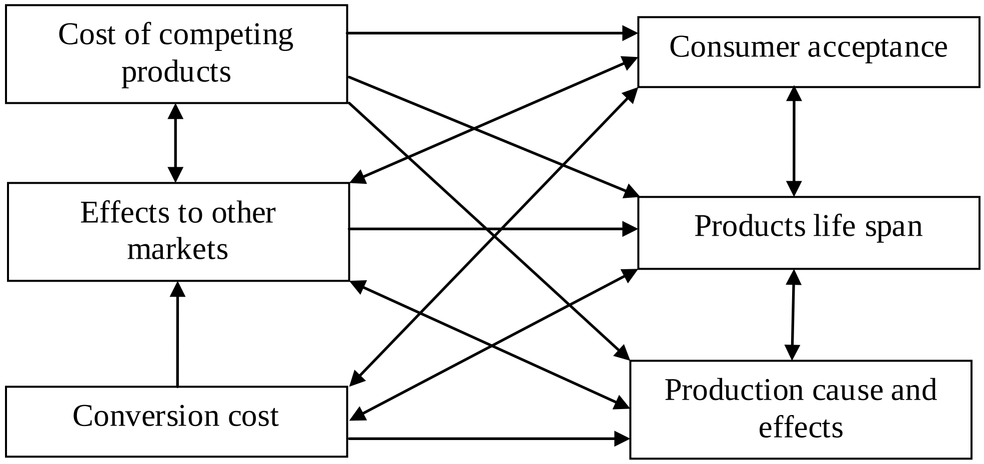

Figure 7: Functional dependency diagram of the processes related to bio-diesel integration.

Table 4: Process variables and their relation: ordered with precedence and succession.

Function	Precedence	Succession
Cost of Competing products	Effects to other markets	Effects to other markets Production cause and effects Products life span Consumer acceptance
Effects to other markets	Production cause and effects Consumer acceptance Conversion cost Cost of Competing products	Production cause and effects Consumer acceptance Products life span Cost of Competing products
Conversion cost	Products life span Consumer acceptance	Effects to other markets Production cause and effects Products life span Consumer acceptance
Consumer acceptance	Products life span Conversion cost Effects to other markets Cost of Competing products	Products life span Conversion cost Effects to other markets
Products life span	Production cause and effects Consumer acceptance Conversion cost Effects to other markets Cost of Competing products	Production cause and effects Consumer acceptance Conversion cost
Production cause and effects	Products life span Conversion cost Effects to other markets Cost of Competing products	Products life span Effects to other markets

Figure 6 shows the flow of these process and their dependencies on one another. As expected the consumer acceptance is a function of the overall success of most all the other processes since increasing efficiency and quality will increase acceptance. Furthermore, the overall life span of the product is based on the consumer acceptance making it a function of everything else. A method must also be created to find the most profitable price point (measured by dollars/gallon) by utilizing all the current resources and capital created. Also to increase the transition process it is important to take into account the possible mixture combinations and possibly even post purchased additives. Table 5 explains a scenario of different possible prices of retail diesel per gallon compared with biodiesel and to which point it becomes more profitable than the non-mixing process. As the amount of bio-diesel mixed increased, the amount profited increased and continued over the profit margin.

Blending bio-diesel offers lots of advantages to help push integration of bio-fuels in the positive direction. Blending renewable fuels in small amounts can basically increase awareness of the opportunities offered by more sustainable energies. Also, blending reduces the use of harmful petroleum fuels that as mentioned causes harmful effects to the environment.

Using biodiesel as a blending component for diesel fuel has environmental benefits, technical benefits and economic benefits to the nation's agriculture. Incorporating just 2% biodiesel in 800 million gallons of on-road, off-road, farm and military diesel fuel used in Minnesota every year will has the benefits outlined below.

6.2.1 Economic Benefits:

Inclusion of biodiesel in on-road diesel fuel at a level of 2% for lubricity purposes would do the following:

- Create demand for more than 40 million gallons of biodiesel.
- Utilize the oil from more than 11 million bushels of soybeans (more than 123 million pounds of soybean oil).
- Add 1.7 to 4.2 cents to the value of a bushel of US soybeans, based on economic analyses conducted by USDA-ERS and FAPRI.
- Increase gross farm income and decrease federal outlays under the soybean marketing loan program in similar amounts.
- Potentially reduce fleet operating costs through increased equipment life.

Additional economic impacts, such as increased employment; increased level of economic activity and corresponding state and local tax revenue; and other indirect and induced economic impacts will also occur.

Table 5: Added Cost to Retail Price of Diesel Fuel when Blended with 20 Percent Biodiesel.

Added Cost to Retail Price of Diesel Fuel when Blended with 2 Percent Biodiesel

Retail Diesel Prices Per Gallon							
	$0.60	$0.75	$0.90	$1.05	$1.20	$1.35	$1.50
Biodiesel Cost 100%	Added Cost in Cents per Gallon						
$1.25	0.013	0.01	0.007	0.004	0.001	-0.002	-0.005
$1.50	0.018	0.015	0.012	0.009	0.006	0.003	
$1.75	0.023	0.02	0.017	0.012	0.011	0.008	0.005
$2.00	0.028	0.025	0.022	0.019	0.016	0.013	0.01
$2.25	0.033	0.03	0.027	0.024	0.021	0.018	0.015

Added Cost to Retail Price of Diesel Fuel when Blended with 20 Percent Biodiesel.

Retail Diesel Prices Per Gallon							
	$0.60	$0.75	$0.90	$1.05	$1.20	$1.35	$1.50
Biodiesel Cost 100%	Added Cost in Cents per Gallon						
$1.25	0.130	0.100	0.070	0.040	0.010	-0.020	-0.050
$1.50	0.180	0.150	0.120	0.090	0.060	0.030	
$1.75	0.230	0.200	0.170	0.140	0.110	0.080	0.050
$2.00	0.280	0.250	0.220	0.190	0.160	0.130	0.100
$2.25	0.330	0.300	0.270	0.240	0.210	0.180	0.150

Source: [Shumaker, 2003]

Depicted in Table 5 are the different possible prices of retail diesel per gallon compared with biodiesel at which point it becomes more profitable than the non-mixing process. As the amount of bio-diesel mixed increased, the amount profited increased once it was over the profit margin. In this analysis the initial value of biodiesel mixed was 2%, the second analysis increased the amount of biodiesel by tenfold and after analysis it can be concluded that the tenfold increase followed as it was ten times more cost efficient once its price point became profitable. This presents satisfactory evidence that at a certain manageable price point bio-diesel mixtures are more profitable than non-mixed diesels.

The above analysis proves that with the correct price point bio-diesel can be profitable and given its sustainable structure it also promotes a self reliant market that can help inflate many other reliant markets. The proper analysis of the surrounding market will be suitable to identify the available resources to manage production location, manufacturing methods, facility size, and available human resources.

6.2.2 Economic Viability of Peanuts

Georgia is the most productive state in the country for producing peanuts, it accounting for approximately 45 percent of the crop's national acreage and production. Last year Georgia farmers harvested 755,000 acres of peanuts, for a yield of 2.2 billion pounds (EPA, 2010). Southern Georgia is the most productive region due to its coastal plain region, which runs from Columbus through Macon to Augusta. Only a few counties in the southern half of the state do not grow peanuts due to their unique geographical features. Below is a map showing the location of the peanut crop production. It can be noted that these southern regions are prominent to a flat plain like regions that are rich in minerals that promote peanut growth.

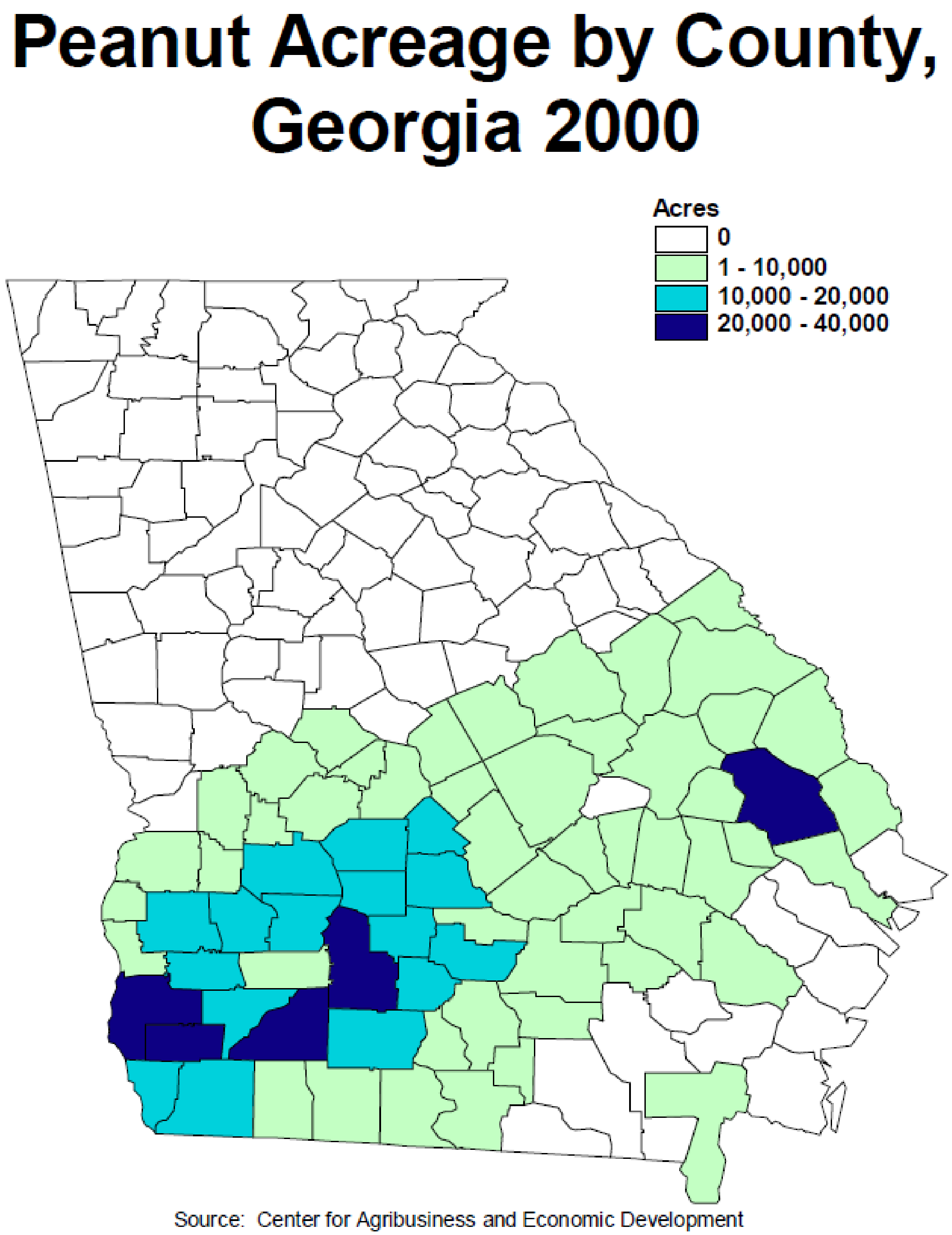

Figure 8: Peanut production by county

Source: [Van Gerpen, 2004]

6.3 Environmental Benefits and Effects of Bio-diesel Integration

Incorporating bio-diesel into the mainstream market will decrease the admittance of emissions from petroleum based fuels. As the usage of bio-diesel increase the emissions from petroleum fuels will decrease due to substitution. Also incorporating clean technologies with in the production facilities and transportation process could also help reduce harmful emissions. On average a 2% biodiesel blend in diesel fuel each year will curtail harmful tailpipe emissions. Annually it will:

- Reduce poisonous carbon monoxide emissions by more than 800 thousand pounds.
- Reduce ozone forming hydrocarbon emissions by almost 91 thousand pounds.
- Reduce hazardous diesel particulate emissions by almost 70 thousand pounds.
- Reduce acid-rain causing sulfur dioxide emissions by more than 70 thousand pounds.

According to the EPA, diesel fuel exhaust contains harmful polycyclic organic matter (POM) that can affect the reproductive, developmental, immunological and endocrine (hormone) systems in humans and in wildlife. Burning just 2% biodiesel in would:

- Reduce harmful and cancerous POM impacts to streams, wildlife and humans by more than 80% for the 16 million gallons of petroleum diesel that would be displaced.

Biodiesel is produced from renewable sources grown and harvested each year, such as soybeans, in what experts call a closed loop carbon cycle. Biodiesel has appropriately been called "solar power, only more feasible." Use of 2% biodiesel each year in would:

- Reduce Life Cycle Carbon Dioxide emissions by more than 250 million pounds. That's enough to fill 5000 semi trailers.
- Extend the fossil diesel supply almost four-fold for every gallon of diesel replaced by biodiesel.

6.4 Manufacturing

The manufacturing processes involved with producing biodiesel will have a significant impact in establishing an economically feasible pricing structure so that the integration will be successful. This is a very complex process that involves multiple factors to create the final manufacturing process. This process will determine the cost of the actual production which will also be the primary determinant of the final cost of the product. Manufacturing includes the use of machines, tools, and labor to produce goods for use or sale. This process starts from the origin of the raw materials and continues until the product is ready for sale. For the creation of a manufacturing process that is not already established this would also include the collection of resources needed to make this process capable. This includes process for the production facility, the process of extracting the raw material efficiently and transporting it to the production facility, it also includes the time and resources required to organize and create the human resources needed to make these process a reality; lastly this production facility would required operating procedures. Once these processes are all organized they would need to be analyzed and establish the full manufacturing process that is most efficient and cost effective.

6.4.1 Available of Human Resources

The process of manufacturing must be accompanied with resources to manufacture and human resources to negotiate them. The region of southern Georgia offers a great distribution of locations to build such facility and have the qualified people manage it. It also has appropriate peanut yields to reduce the need for transportation of raw materials. From Columbus to Macon, and across to Augusta there are substantial resources of strong agriculture based human resources. Give their rural location there are high numbers of colleges producing highly qualified human resources into the work field in these locations. These Universities include:

- Abraham Baldwin Agricultural College, Tifton
- Albany State University, Albany
- Armstrong Atlantic State University, Savannah
- Augusta State University, Augusta
- College of Coastal Georgia, Brunswick
- Columbus State University, Columbus
- Darton College, Albany
- East Georgia College, Swainsboro
- Fort Valley State University, Fort Valley
- Georgia College and State University, Milledgeville
- Georgia Southern University, Statesboro
- Georgia Southwestern State University, Americus
- Macon State College, Macon
- Middle Georgia College, Cochran
- Savannah State University, Savannah
- Valdosta State University, Valdosta
- Waycross College, Waycross

These universities are continuously producing young and qualified graduates in areas of Production and Manufacturing Management, Engineering, Construction Management, Biology, Physics, etc. This creates a younger population within the work force that can help build the production and offers secure and substantial income to the employees. The need for more qualified and experienced human resources can be met through local interest and possible relocation. The allocation of such people could also come from the over 20 electrical power plants already in existence within the region or any other large scale relatable industry.

6.4.2 Crop Yields

Beginning at the extraction of raw materials, in this case peanuts will be the first step in manufacturing. The most logical source for this product would be Georgia to reduce transportation cost and time. This would not only cut cost directly but offer an expansive increase in the peanut market with the increase of demand. Depicted in Figure 7, Georgia's primary location for peanut production is in the southern region of the state. This is due to the rural and less developed and predominantly flat land that is also rich in minerals that support such product growth. The extraction of peanuts will serve as a major beneficiary to the inclusiveness of this process. Table 7 shows the production of peanuts across the state and is separated by physical acres harvested, yield per acre, price per pound, and farm gate value.

Table 6: Georgia Peanut Production by County

Georgia Peanut Production by County				
County	Acres Harvested,	Avg Yield/acre	Avg Price/lb,	Farm Gate Value,
Appling	9,511	3,400	$0.20	$6,467,480
Atkinson	6,631	3,530	$0.20	$4,681,486
Bacon	8,600	3,350	$0.20	$5,762,000
Baker	18,000	4,100	$0.20	$14,760,000
Baldwin	0	0	$0.00	$0
Banks	0	0	$0.00	$0
Barrow	0	0	$0.00	$0
Bartow	0	0	$0.00	$0
Ben_Hill	5,678	3,550	$0.20	$4,031,380
Berrien	13,695	3,400	$0.20	$9,312,600
Bibb	0	0	$0.00	$0
Bleckley	1,199	3,300	$0.20	$791,340
Brantley	802	2,800	$0.20	$449,064
Brooks	9,613	3,600	$0.20	$6,921,360
Bryan	195	3,000	$0.20	$117,000
Bulloch	14,061	3,200	$0.20	$8,999,040
Burke	15,000	3,300	$0.20	$9,900,000
Butts	0	0	$0.00	$0
Calhoun	14,616	4,700	$0.20	$13,739,040
Camden	0	0	$0.00	$0
Candler	2,500	3,600	$0.20	$1,800,000
Carroll	0	0	$0.00	$0
Catoosa	0	0	$0.00	$0
Charlton	0	0	$0.00	$0
Chatham	0	0	$0.00	$0
Chattahoochee	0	0	$0.00	$0
Chattooga	0	0	$0.00	$0
Cherokee	0	0	$0.00	$0
Clarke	0	0	$0.00	$0
Clay	7,293	4,000	$0.20	$5,834,320
Clayton	0	0	$0.00	$0
Clinch	261	3,000	$0.20	$156,600
Cobb	0	0	$0.00	$0
Coffee	15,340	2,850	$0.20	$8,743,800
Colquitt	15,660	3,866	$0.20	$12,108,312
Columbia	0	0	$0.00	$0
Cook	8,120	3,460	$0.20	$5,619,040

Georgia Peanut Production by County				
County	Acres Harvested,	Avg Yield/acre	Avg Price/lb,	Farm Gate Value,
Coweta	0	0	$0.00	$0
Crawford	96	3,150	$0.20	$60,480
Crisp	9,900	3,600	$0.20	$7,128,000
Dade	0	0	$0.00	$0
Dawson	0	0	$0.00	$0
Decatur	22,515	5,000	$0.20	$22,514,900
Dekalb	0	0	$0.00	$0
Dodge	3,800	3,500	$0.20	$2,660,000
Dooly	21,249	3,800	$0.20	$16,149,240
Dougherty	2,800	3,750	$0.20	$2,100,000
Douglas	0	0	$0.00	$0
Early	22,607	4,250	$0.20	$19,215,950
Echols	0	0	$0.00	$0
Effingham	1,750	3,000	$0.20	$1,050,000
Elbert	0	0	$0.00	$0
Emanuel	6,301	3,500	$0.20	$4,410,700
Evans	886	3,900	$0.20	$691,080
Fannin	0	0	$0.00	$0
Fayette	0	0	$0.00	$0
Floyd	0	0	$0.00	$0
Forsyth	0	0	$0.00	$0
Franklin	0	0	$0.00	$0
Fulton	0	0	$0.00	$0
Gilmer	0	0	$0.00	$0
Glascock	1,600	2,400	$0.20	$768,000
Glynn	0	0	$0.00	$0
Gordon	0	0	$0.00	$0
Grady	9,134	4,165	$0.20	$7,608,622
Greene	0	0	$0.00	$0
Gwinnett	0	0	$0.00	$0
Habersham	0	0	$0.00	$0
Hall	0	0	$0.00	$0
Hancock	0	0	$0.00	$0
Haralson	0	0	$0.00	$0
Harris	0	0	$0.00	$0
Hart	0	0	$0.00	$0
Heard	0	0	$0.00	$0
Henry	0	0	$0.00	$0

Georgia Peanut Production by County				
County	Acres Harvested,	Avg Yield/acre	Avg Price/lb,	Farm Gate Value,
Houston	3,844	3,450	$0.20	$2,652,360
Irwin	18,354	3,530	$0.20	$12,957,924
Jackson	0	0	$0.00	$0
Jasper	0	0	$0.00	$0
Jeff_Davis	6,865	3,750	$0.20	$5,148,750
Jefferson	7,264	3,390	$0.20	$4,924,992
Jenkins	5,600	2,850	$0.20	$3,192,000
Johnson	585	3,000	$0.20	$351,000
Jones	0	0	$0.00	$0
Lamar	0	0	$0.00	$0
Lanier	2,300	3,950	$0.20	$1,817,000
Laurens	1,655	2,300	$0.20	$761,300
Lee	12,213	3,500	$0.20	$8,548,820
Liberty	0	0	$0.00	$0
Lincoln	0	0	$0.00	$0
Long	100	3,500	$0.20	$70,000
Lowndes	3,000	3,400	$0.20	$2,040,000
Lumpkin	0	0	$0.00	$0
Macon	4,690	4,000	$0.20	$3,752,000
Madison	0	0	$0.00	$0
Marion	1,303	2,920	$0.20	$761,069
Mcduffie	0	0	$0.00	$0
Mcintosh	0	0	$0.00	$0
Meriwether	0	0	$0.00	$0
Miller	17,337	5,050	$0.20	$17,510,370
Mitchell	22,975	4,700	$0.20	$21,596,500
Monroe	0	0	$0.00	$0
Montgomery	438	2,600	$0.20	$227,916
Morgan	0	0	$0.00	$0
Murray	0	0	$0.00	$0
Muscogee	0	0	$0.00	$0
Newton	0	0	$0.00	$0
Oconee	0	0	$0.00	$0
Oglethorpe	0	0	$0.00	$0
Paulding	0	0	$0.00	$0
Peach	903	2,700	$0.20	$487,620
Pickens	0	0	$0.00	$0
Pierce	5,520	3,100	$0.20	$3,422,400

Georgia Peanut Production by County				
County	Acres Harvested,	Avg Yield/acre	Avg Price/lb,	Farm Gate Value,
Pike	0	0	$0.00	$0
Polk	0	0	$0.00	$0
Pulaski	7,500	2,950	$0.20	$4,425,000
Putnam	0	0	$0.00	$0
Quitman	879	3,800	$0.20	$668,116
Rabun	0	0	$0.00	$0
Randolph	8,286	4,184	$0.20	$6,933,725
Richmond	50	3,200	$0.20	$32,000
Rockdale	0	0	$0.00	$0
Schley	706	2,500	$0.20	$352,950
Screven	5,522	5,000	$0.20	$5,522,000
Seminole	14,037	4,500	$0.24	$15,159,960
Spalding	0	0	$0.00	$0
Stephens	0	0	$0.00	$0
Stewart	1,768	3,000	$0.20	$1,060,800
Sumter	8,820	3,900	$0.20	$6,879,600
Talbot	0	0	$0.00	$0
Taliaferro	0	0	$0.00	$0
Tattnall	568	3,850	$0.20	$437,360
Taylor	550	2,700	$0.20	$297,000
Telfair	2,610	3,750	$0.20	$1,957,500
Terrell	7,453	3,250	$0.20	$4,844,450
Thomas	7,653	3,840	$0.20	$5,877,504
Tift	11,940	3,750	$0.20	$8,955,000
Toombs	1,100	3,530	$0.20	$776,600
Towns	0	0	$0.00	$0
Treutlen	414	3,200	$0.20	$264,960
Troup	0	0	$0.00	$0
Turner	13,125	2,800	$0.20	$7,350,000
Twiggs	2,050	2,850	$0.20	$1,168,500
Union	0	0	$0.00	$0
Upson	0	0	$0.00	$0
Walker	0	0	$0.00	$0
Walton	0	0	$0.00	$0
Ware	1,348	3,100	$0.20	$835,760
Warren	500	2,300	$0.20	$230,000
Washington	918	3,400	$0.20	$624,240
Wayne	3,213	3,500	$0.20	$2,249,100

Georgia Peanut Production by County				
County	Acres Harvested,	Avg Yield/acre	Avg Price/lb,	Farm Gate Value,
Webster	2,609	3,300	$0.20	$1,721,940
Wheeler	791	3,290	$0.20	$520,478
White	0	0	$0.00	$0
Whitfield	0	0	$0.00	$0
Wilcox	13,500	2,800	$0.20	$7,560,000
Wilkes	0	0	$0.00	$0
Wilkinson	53	3,000	$0.20	$31,800
Worth	26,971	3,650	$0.20	$19,688,830
Georgia	529,293	3,766	$0.20	$401,198,028

Source: [EPA, 2010]

The physical acres harvested, yield per acre, price per pound, and farm gate value can be recognized in this table separated by county for the state of Georgia. Notice the immense amount of money that impacts the economy of these areas. It can also be noted that most of the areas are less developed and maintain smaller economies.

6.4.3 Peanut production Cost

Starting from the beginning process of the production of the peanut based bio-diesel; the actual cost and availability of the peanut as a raw material serves as a major constraint. Once the raw material is available at the correct price to make the manufacturing process profitable, the next process is creating a place to store the product during the different steps of the process.

Table 7 South Georgia, Estimated Costs and Returns of Peanut Crops: Actual Peanut Production

Variable Costs	Unit	Number of Units	$/Unit	Cost/Acre	$/Ton
Seed	Lb.	115	$0.52	$59.80	$42.71
Inoculant	Lb.	5	$1.40	$7.00	$5.00
Lime/Gypsum	Ton	0.5	$63.00	$31.50	$22.50
Fertilizer					
Phospate (P2O5)	Lb.	20	$0.31	$6.20	$4.43
Potash (K2O)	Lb.	40	$0.23	$9.20	$6.57
Boron	Lb.	0.5	$3.75	$1.88	$1.34
Weed Control	Acre	1	$41.46	$41.46	$29.61
Insect Control	Acre	1	$25.48	$25.48	$18.20
Disease Control*	Acre	1	$68.40	$68.40	$48.86
Machinery: Pre-harvest					
Fuel	Gallon	9.48	$2.25	$21.32	$15.23
Repairs & Maintenance	Acre	8.19	$2.25	$18.43	$13.16
Machinery: Harvest					
Fuel	Gallon	1	$13.80	$13.80	$9.86
Repairs & Maintenance	Acre	1	$16.28	$16.28	$11.63
Labor	Hrs	2.53	$10.00	$25.29	$18.06
Crop Insurance	Dol.	1	$15.00	$15.00	$10.71
Land Rental	Acre	1			
Interest on Operating capital	Percent	$180.51	8.00%	$14.44	$10.32
Cleaning	Ton	0.47	$10.50	$4.90	$3.50
Drying	Ton	0.93	$26.00	$24.28	$17.34
GPC&GPPA State	Ton	1.4	$3.00	$4.20	$3.00
NPB Check off	Dol.	1%	$532.00	$5.32	$3.80
Total variable Cost				$414.16	$295.83

Source: [Shumaker, 2007]

The first activity in the process is to shell the peanut so that the shells will not be included in the crushing process. In the first step of the shelling process, peanuts are cleaned; removing stones, soil, bits of vines and other foreign materials that are commonly harvested along with the nuts. The cleaned peanuts move by conveyor to shelling machines where peanuts are de-hulled as they are forced through perforated grates. The peanuts then pass through updraft air columns that separate the kernels from the hulls. Specific gravity machines separate the kernels and the unshelled pods. The kernels are then passed over the various perforated grading screens where they are sorted by size into market grades. Selecting a process in which the hull is not wasted is also important because the hull can also be sold and used to make other products such as chemicals and flour. This helps utilize all parts of the raw material and decrease waste and create a more sustainable market. The next part of the process is the extraction of oil by crushing the peanuts; this is done with various compression and crushing procedures that extract the oil for use. Once the oil is extracted it can then be refined so that it can be used for production.

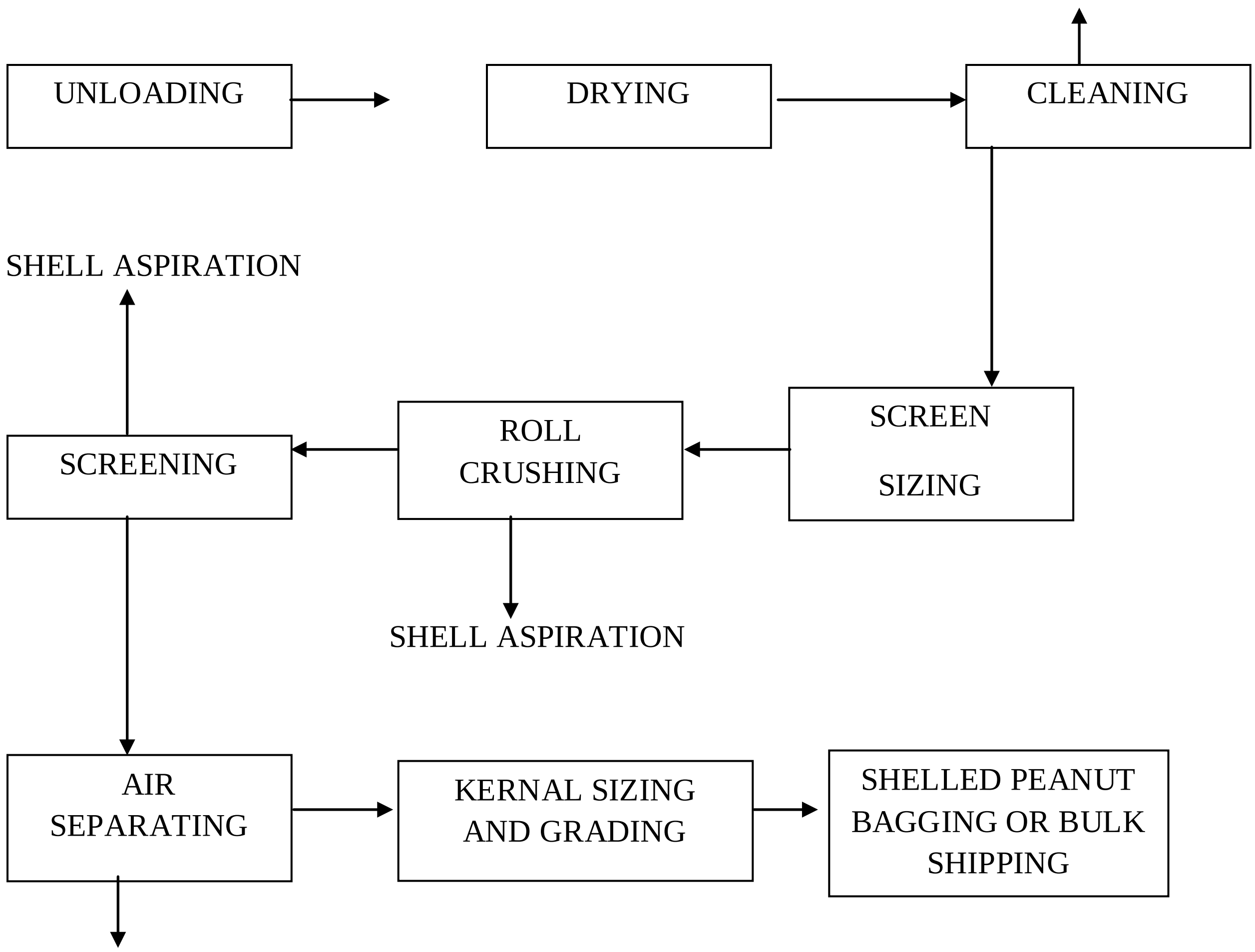

Figure 9: Shelling process flow diagram for peanuts start to finish

Source: [Shumaker, 2007]

6.4.4 Production Process for Shelling and Peanut Preparation

Shelling begins with separating the foreign material with a series of screens, blowers, and magnets. The cleaned peanuts are then sized with screens (size graders). Sizing is required so that peanut pods can be crushed without also crushing the peanut kernels. Next, shells of the sized peanuts are crushed, typically by passing the peanuts between rollers that have been adjusted for peanut size. Following crushing and hull/kernel separation, peanut kernels are sized and graded. Lastly they are bagged and shipped.

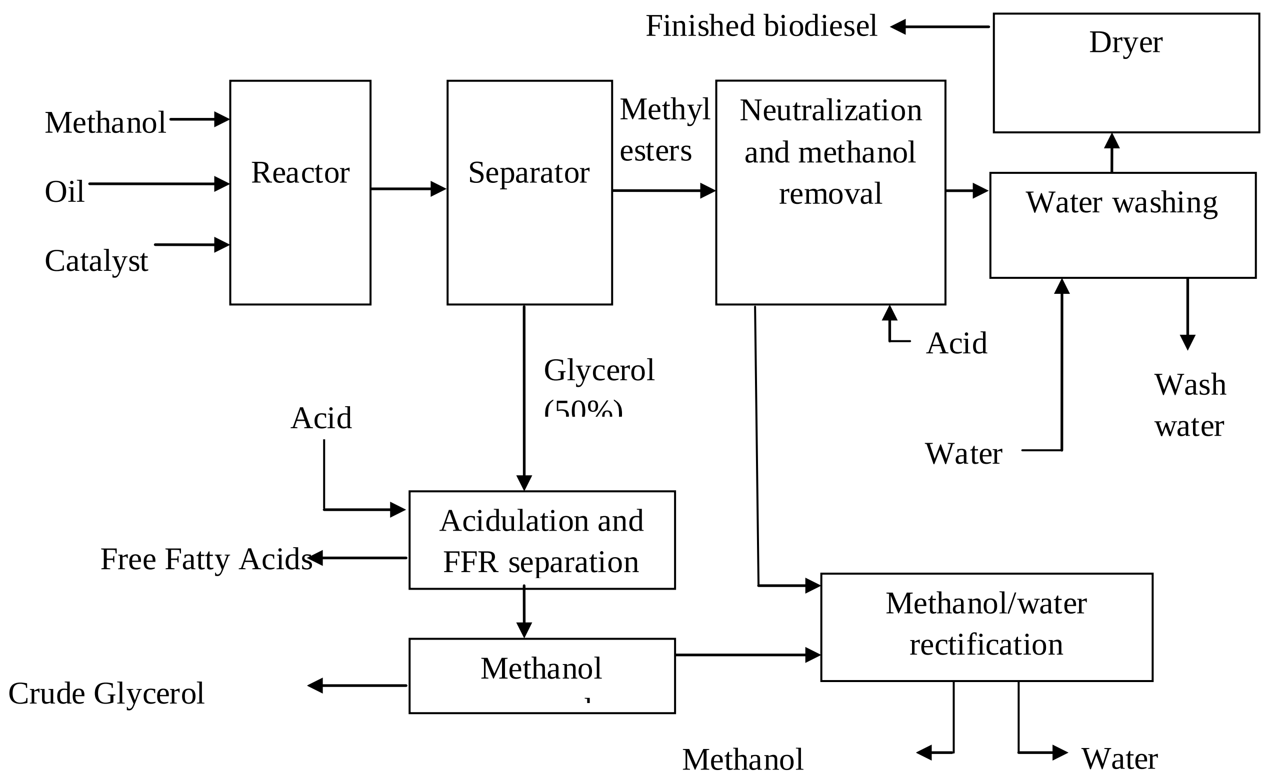

Figure 10: Schematic diagram of the processes involved in commercial-scale biodiesel production

Source: [Van Gerpen, 2004]

6.4.5 Process Flow Schematic for Biodiesel Production

Figure 10, shows a schematic diagram of the processes involved in commercial-scale biodiesel production. Alcohol, catalyst and oil are combined in a reactor and agitated for approximately an hour at 60ºC. Smaller plants often use batch reactors, but larger plants (> 4 million liters/year) use continuous flow processes involving continuous stirred-tank reactors (CSTR) or plug flow reactors.

This reaction is sometimes done in two steps. In this system, approximately 80 percent of the alcohol and catalyst is added to the oil in a first-stage CSTR. Then the reacted stream from this reactor goes through a glycerol removal step before entering a second CSTR. The remaining 20 percent of the alcohol and catalyst is added in this reactor. This system provides a very complete reaction with the potential of using less alcohol than single-step systems.

6.4.6 Glycerol Separation

Following the reaction, the glycerol is removed from the methyl esters. Due to the low solubility of glycerol in the esters, this separation generally occurs quickly and may be accomplished with either a settling tank or a centrifuge. The excess methanol tends to act as a solubilizer and can slow the separation. However, this excess methanol is usually not removed from the reaction stream until after the glycerol and methyl esters are separated, because the transesterification reaction is reversible and the methyl esters may recombine with glycerin to form monoglycerides.

The glycerol stream leaving the separator is only about 50 percent glycerol. It contains some of the excess methanol and most of the catalyst and soap. In this form, the glycerol has little value and disposal may be difficult. The methanol content requires the glycerol to be treated as hazardous waste.

The first step involved with refining the glycerol is to add acid to assist splitting the soaps into free fatty acids and salts. The free fatty acids are not soluble in the glycerol and will rise to the top, where they can be removed and recycled. The salts remain with the glycerol, although depending on the chemical compounds present, some may precipitate out. One frequently touted option is to use potassium hydroxide as the reaction catalyst and phosphoric acid for neutralization, so that the salt formed is potassium phosphate, which can be used for fertilizer. After acidulation and separation of the free fatty acids, the methanol in the glycerol is removed by a vacuum flash process, or another type of evaporator. At this point, the glycerol should have a purity of approximately 85 percent and this is typically sold to a glycerol refiner. The glycerol refining process takes the purity up to 99.5 percent to 99.7 percent, using vacuum distillation or ion exchange processes (Van Gerpen, 2010).

6.4.7 Methanol Separation

After separation from the glycerol, the methyl esters pass through a methanol stripper, usually a vacuum flash process or a falling film evaporator, before entering a neutralization step and water washing. Acid is added to the biodiesel to neutralize any residual catalyst and to split any soap that may have formed during the reaction. Soaps will react with the acid to form water-soluble salts and free fatty acids. The salts will be removed during the water washing step and the free fatty acids will stay in the biodiesel.

The methanol that is removed from the methyl ester and glycerol streams will tend to collect any water that may have entered the process. This water should be removed in a distillation column before the methanol is returned to the process. This step is more difficult if an alcohol such as ethanol or isopropanol is used that forms an azeotrope with water. Then, a molecular sieve is used to remove the water (Van Gerpen, 2010).

6.4.8 Washing the Biodiesel

A water washing step is intended to remove any remaining catalyst, soap, salts, methanol or free glycerol from the biodiesel. Neutralization before washing reduces the water required and minimizes the potential for emulsions to form when the wash water is added to the biodiesel. Following the wash process, any remaining water is removed from the biodiesel by a vacuum flash process. In recent years, so-called waterless wash processes have been developed that minimize the need for waste water treatment and disposal.

6.4.9 Handling Free Fatty Acids

Special processes are required if the oil or fat contains significant amounts of free fatty acids (FFAs). Used cooking oils typically contain 2 percent to 7 percent FFAs, and animal fats contain from 5 percent to 30 percent FFAs. When an alkali catalyst is added to these feed stocks, the free fatty acid reacts with the catalyst to form soap and water, as shown in the reaction below.

Fatty Acids		Potassium Hydroxide		Potassium oleate (soap)		Water
O ‖	+	KOH	→	O ‖ K – O – C – R	+	H_2O

Figure 11: Reaction process for free fatty acids

Source: [Van Gerpen, 2010]

With up to about 5 percent FFAs, the reaction can still be catalyzed with an alkali catalyst, but additional catalyst must be added to compensate for the catalyst lost to soap. The soap that is created during the reaction is washed out after the reaction with the water wash.

When the FFA level is above 5 percent, the soap inhibits separation of the methyl esters and glycerol and contributes to emulsion formation during the water wash. In these cases, an acid catalyst such as sulfuric acid can be used to esterify the free fatty acids to methyl esters as shown in the following reaction.

$$\overset{O}{\|} \quad + \quad CH_3OH \quad \xrightarrow{(H_2SO_4)} \quad CH_3-O-\overset{\overset{O}{\|}}{C}-R \quad + \quad H_2O$$

Figure 12: Conversion pretreatment process to convert the FFAs in high FFA feedstock's to methyl esters, and thereby reduce the FFA level

Source: Van Gerpen [2010]

This process can be used as a pretreatment to convert the FFAs in high FFA feedstock's to methyl esters, and thereby reduce the FFA level. Then, the low FFA pretreated oil can be transesterified with an alkali catalyst to convert the triglycerides to methyl esters. As shown in the reaction, water is formed, and if it accumulates it can stop the reaction well before completion (Van Gerpen, 2010).

Table 8: Derived Farm Values of Peanuts for Biodiesel

Activity	Traditional Methods	Extruder Process	Minimum Cost Method
Shelling			
Storage, Transport, Handling Cost	$111.00	$111.00	$100.00
Shelling Cost	$51.00	$51.00	$20.00
Shelling yield	76.5%	76.5%	76.5%
Storage, Shelling & Handling Shrink	7.0%	7.0%	7.0%
Shelled peanuts in lbs	1,390	1,390	1,390
Peanut Hulls in lbs	437	437	437
Peanut Hull Price per ton	$5.00	$5.00	$5.00
Peanut Hull Value	$1.09	$1.09	$1.09
Crushing			
Crush Cost of Shelled Peanuts	$60.00	$50.00	$50.00
Crushing Cost Farmer Stock Ton	$45.90	$38.25	$38.25
Oil yield	48.00%	44.00%	44.00%
Oil yield in pounds	667	612	612
Oil share of crush costs	$22.03	$16.83	$16.83
Per pound oil crush costs	$0.033	$0.028	$0.028
Meal yield	52.00%	56.00%	56.00%
Meal yield in tons	0.36	0.39	0.39
Meal Price per Ton	$105.00	$110.00	$110.00
Meal Value	$37.95	$42.81	$42.81
Meal share of crush costs	$23.87	$21.42	$21.42
Net Meal Value	$14.08	$21.39	$21.39
Refining - degumming cost / lb	$0.025	$0.025	$0.025
Total Refining Cost	$16.68	$15.29	$15.29
Biodiesel Production			
Peanut oil to Biodiesel Yield	96.0%	96.0%	96.0%
Biodiesel Production @ 7.5 lbs/gal	85.4	78.3	78.3
Biodiesel Production Cost per Gal.	$0.70	$0.70	$0.70
Biodiesel Sales Price per Gallon	$2.70	$2.70	$2.70
Crude Glycerin Co-Product - lbs	67.8	62.2	62.2
Crude Glycerin Co-Product Price	$0.03	$0.03	$0.03
Crude Glycerin Co-Product Value	$2.03	$1.86	$1.86
Gross Biodiesel Oil Value	$230.58	$213.23	$213.23
Cost of Biodiesel Production	$62.27	$57.08	$57.08
Net Biodiesel Value	$168.31	$156.15	$156.15
Implied Oil Value Based on Biodiesel Value	$0.252	$0.255	$0.255

$/lb.			
Gross Product Value	$271.66	$259.00	$259.00
Total System Cost	$286.85	$272.62	$230.62
Value Net of All Costs	-$15.19	-$13.62	$28.38

Source: [Shumaker, 2007]

The farm value of the peanut crop when the oil is used for biodiesel production can be determined by the combining the values of the two main products of the peanut – the biodiesel value of the oil and the value of the meal. The following worksheet illustrates the economics under three scenarios:

1. Using the current traditional methods for shelling, oil extraction, and oil refining and biodiesel production.
2. Using an extruder to press the oil rather than using hexane extraction.
3. Using estimated minimum costs methods for shelling and oil extraction.

The worksheet is broken into four main sections dealing with the various processes needed to produce biodiesel from farmer stock peanuts. Each step has been modeled based on detailed Center for Agriculture Economic Development feasibility studies of the processing steps. The analysis shown is based upon the costs and returns for one farmer stock ton of peanuts. To illustrate the analysis view the column "Traditional Methods". The data presented in the column is explained as follows:

- Typical storage, transport and handling costs for one farmer stock ton are about $111.00.
- Shelling costs are about $51.00 per ton.
- There is an estimated 7% shrink loss in the handling process.

- Thus one farmer stock ton yields about 1,390 pounds of shelled peanuts and about 437 pounds of hulls.
- The hulls would be worth about $1.09.
- The crush or oil extraction costs about $45.90 for the nuts from the original ton and would yield about 667 pounds of oil and about 720 pounds of peanut meal (.36 ton).
- The meal would be worth about $37.95.
- The crude oil must be de-gummed, refined and bleached to make it suitable for biodiesel production for a cost of about $16.68.
- The oil from one farmer stock ton will yield about 85.4 gallons of biodiesel with production costs of about $0.70 per gallon.
- The net biodiesel value after all costs and sales of by-products is about $168.31.
- The total revenues generated from one farmers stock ton would be about $271.65.
- Total costs of operation would total near $286.85.
- Negative net residual of about - $15.19.
- Using traditional method of processing a typical farmer would incur a loss of $15.19.

So, given the current markets for peanut meal, hulls and biodiesel and traditional processing methods, farmer stock peanuts have a negative value to the processor. The implied value of the peanut oil for biodiesel production is about $0.2522 cents per pound. This is well below the early February, 2007 price of about $0.51 per pound (Shumaker, 2003).

Only a hypothesized system designed to handle oil-only peanuts (minimum cost method) shows potential for a positive price being paid to peanut producers. However, this is only about $30 per ton, certainly not in the range of reasonable production cost even with minimum inputs. Rather than evaluating what, if anything can be paid to producers for peanuts under current biodiesel and meal prices, one might evaluate what the biodiesel markets have to reach to make minimum input peanut production for Biodiesel profitable. In order to evaluate such a scenario, one would have to know what minimum input peanut production cost to produce. No definitive cost analysis are known to the researchers, but an evaluation of traditional peanut production cost in light of optimistic assumptions of those inputs most likely to be reduced revealed that:

- Variable cost may be reduced to around $200 per acre (from $414/acre).
- Fixed cost cannot be appreciably reduced so that equipment ownership may represent about another $90/acre.
- Thus to cover variable cost at a 1.4 ton per acre yield, the break-even price would be $142/ton.
- To cover total cost of $290/acre, the breakeven price would be $207/ton.
- Under the minimum cost scenario, the total cost of production would be returned at $5.00/ gal of biodiesel or an approximate 185% increase over current prices.
- The traditional system would require Biodiesel prices to reach about $5.35/gal.
- In order to return producers their total production cost, approximately double current biodiesel prices (Shumaker, 2003).

The implied oil price shows what the value of oil would be when subtracting at the different biodiesel levels. Interestingly, at implied oil prices of roughly 55 cents per pound, roughly 10% higher than current peanut oil prices, processors would be able to pay around the total hypothesized minimum input break-even price to producers. Thus while minimum input peanut production for Biodiesel appears far from feasible, peanuts produced for the edible oil market may not. Once the derived production process and costs are assessed the feasibility of the actual facility and production yields can be assessed. This will help determine the size and type of facility and processes will be used. Location will be a key process in this process due to the available local resources. The type of equipment, buildings, and utilities will also determine the overall feasibility of the success of the facility. Once these factors can be decide on, it could then be logical for the consultants, engineers, and architects to move forward with the conceptual ideas of the facility and its capacity. The Table 9 is and analysis of how each factor is costly represented for a 15 million gallon production plant in Georgia. It is important to look at the underlying cost that is beyond the facility and production equipment and notice the cost of permits, consulting, and other cost that are easily overlooked and can have large effects on the overall cost of creating and maintaining a production facility.

6.4.10 Glycerol By-product

One major concern regarding biodiesel production is not with the fuel itself, but rather with the major by-product of biodiesel production, glycerol. In general, biodiesel production generates 10% weight crude glycerol. Purified glycerol, or glycerin, is a fairly high-value commercial chemical, historically valued at \$0.60–\$0.90/lb, that is primarily used in the manufacture of various foods and beverages, pharmaceuticals, cosmetics, and other personal care products. Unfortunately, commercial development of alternative processes for glycerol utilization has been limited, as the price of glycerol has made it economically unattractive as a feedstock chemical. Recently, however, the price of crude glycerol has fallen to about \$0.05 per lb, primarily because of the increased production of biodiesel. Because of this significant price decrease, glycerol is poised to emerge as an important building block chemical. Transporting these large quantities of glycerol are a logistical nightmare. Considering that the current U.S. market for glycerol is about

600 million lbs/year, conventional uses of glycerol simply cannot accommodate such an excess, and increasing biodiesel production is creating a significant glut in the glycerol market (Johnson, *et al* 2007).

6.4.11 Sustainability of Bio-diesel Plant

From a production stand point the excess glycerol from creating bio-diesel has the potential to be used as an energy source. Glycerol can be placed in a convection oven that can be used to heat and even used to convert to electricity. The oven will burn glycerol and peanut shells, this process offers potential for a more sustainable production process that creates less waste and cuts cost at the same time. The investment of the equipment necessary to reintroduce glycerol into the production process would be very effective and would quickly pay itself off. This process also leaves the opportunity for growth and efficiency

6.4.11 The Economics of Biodiesel Production

The Center for Agribusiness and Economic Development at the University of Georgia secured the services of Frazier, Barnes & Associates (FBA, 2005) of Memphis, TN, a consulting firm specializing in vegetable oil processing, to assess the capital cost of various sized biodiesel production facilities. Each of the plant cost estimates are for a facility capable of handling a wide variety of feed stocks for biodiesel production. The capital cost estimates include the cost of facilities needed to pre-process any feedstock such that it could be converted to biodiesel using the aforementioned methyl ester process. FBA evaluated four different sized biodiesel site production plants looking closely at estimated construction and operating costs.

Tables 9 and 10 present a summary of the findings:

Table 9: Estimated Capital Cost Comparison of Various Plant Sizes

Estimated Capital Cost Comparison of Various Plant Sizes.				
Plant Size (million gallon/yr)	0.5	3	15	30
Capital Cost	$950,000	3.4 million	$9.6 million	$15 million
Feedstock Needed Pounds Gallons	 3.75 million 500,000	 22.5 million 3 million	 112.5 million 15 million	 225 million 30 million

- Assumes a green field site.
- Estimated Accuracy +/- 25%.
- Total includes capital cost for preprocessing feedstock.

Source: Frazier, Barnes & Associates [FBA, 2005]

The capital cost range from $950,000 to $15 million depending on the capacity of the operation. The feedstock needed to run at full capacity ranged from 3.75 million pound at the smallest level of production to 225 million pounds at the highest level of production.

Table 10: Production cost sensitivity to feedstock cost by plant size, dollars per gallon of biodiesel.

Production Cost Sensitivity to Feedstock Cost by Plant Size, Dollars Per Gallon of Biodiesel.				
Plant Size (million gallon/yr)	0.5	3	15	30
$0.10 per lb cost	$1.96	$1.33	$1.11	$1.10
$0.15 per lb cost	$2.34	$1.70	$1.48	$1.48
$0.20 per lb cost	$2.72	$2.08	$1.85	$1.85
$0.25 per lb cost	$3.09	$2.46	**$2.21	$2.21

Source: Frazier, Barnes & Associates [FBA, 2005]

Based on the data provided in Tables 9 and 10, it appears the most appropriate size facility for Georgia is the one that produces about 15 million gallons of biodiesel per year with a capital cost of about $9.6 million. In Table 9 we see that most of the economies of scale are realized in a 15 million gallon plant. Unit costs of production do not appear to fall by doubling the size to 30 million gallons. Therefore, the remainder of this report will focus on a plant size of 15 million gallon capacity. It must be taken that the most profitable size for production is 15 million gallon capacity with the price per produced gallon of bio-diesel is $2.21.

Table 11: Estimated Biodiesel Capital Cost Details for a 15 Million Gallon Capacity Plant

Estimated Biodiesel Capital Cost Details for a 15 Million Gallon Capacity Plant.	
Equipment	$3,600,000
Convection Oven	$1,000,000
Buildings	$1,200,000
Utilities	$720,000
Civil/Mechanical/Electrical	$2,736,000
Land/Prep/Trans Access	$192,000
Engineering/Permitting	$192,000
Set-up Consulting	$3,000
Contingency (10%)	$960,000
Total Installed Cost	$10,603,000

Source: [Shumaker, 2003]

Presented in Table 11 is the breakdown of the capital cost components of a 15 million gallon per year capacity biodiesel production facility. The cost estimates represent a 'turn-key' facility placed upon a green site near transportation access.

Once the facility is in place its relevance to the community's economy will need to be accessed to evaluate the revenue and potential growth for the local economy. The physical plant would require approximately 7 to 10 acres for the building, tank farm and transportation areas. A buffer zone may require more land depending upon the surrounding level of development. The building needed to house the plant would be approximately 5,000 square feet and about 60 feet in height. It would contain all the processing equipment plus a laboratory for quality control and offices. The processing area would use about 3,400 square feet. The tank farm may utilize about 20,000 square feet and would contain tanks totaling 650,000 gallon capacity divided between both holding tanks for feedstock and finished product. This plant would operate continuously and stop production only for maintenance and repair. It would require an operating employment force of eight people plus six people in management, sales, accounting and clerical (Shumaker, 2003).

The establishment of such facility and processes would result in development and growth in employment, sales, and revenue. This development would stimulate the economy and offer opportunities for growth that would indirectly affect other markets and resources. This expansion would be relatable to multiple areas of concern across the entire economy.

Table 12: Economic Impact on Sales, Employment and Revenue of a 15 Million Gallon Biodiesel Plant in Georgia.

Economic Impact on Sales, Employment and Revenue of a 15 Million Gallon Biodiesel Plant in Georgia.			
	Direct	Indirect	Total
Sales (Output)	$17,373,000	$16,899,714	$34,272,716
Employment (# of employees)	7	76	83
Tax Revenue	NA	NA	$2,116,870

Source: [Shumaker, 2003]

6.5 Cost versus Petroleum Based Fuels

The most important variable in the process of integration of bio-diesel into the local southern Georgia market is the actual price of the final product compared to the existing product. If the price of the peanut based fuel is less expensive it becomes more feasible as a viable alternative to petroleum based fuels. As the price rises it becomes less feasible. It is important to note that this is just an experiment and the data confidence is based on research analysis based on statistical data. The process of comparison of the current diesel prices compared to the peanut based bio-diesel presented in the precedence is based on current prices of wholesale crude oil prices verses the production cost of the process aforementioned.

Crude oil price per barrel most often refers to the spot price of petroleum per barrel. A barrel of petroleum is equal to 159 liters or 42 gallons. In relation to the wholesale diesel price structure it is the most commonly changing variable due to the constant change in price due to revolving issues in countries that supply large quantities or demand large quantities of crude oil. If a country that consumes large quantities is at war or ridden with a national scale disaster the price tends to rise, the same applies to a country that supplies large quantities of crude oil to the global population. This portion of the wholesale diesel price structure is generally the cause of the mass fluctuation of fuel prices worldwide. The information and up-to-date crude oil prices can be found on the U.S. Energy Information Administration’s website (EIA, 2010).

The process required to refine crude oil into production ready wholesale diesel is mostly a constant proportion within the wholesale biodiesel price structure since it is only reliant on the manufacturer’s efficiency and production capabilities. In 2003, University of Georgia’s George Shumaker presented the following base formula to break down the methods and production process behind wholesale biodiesel:

WDP = Crude Oil Price per Barrel / 42 gallons + Processing ($0.05/gal) + Transportation ($0.02) + Profit ($0.05)

WDP = $25.11 (March 19, 2002) /42 + $.12 = $0.72 per gallon

This formula can be applied with minor changes to the process and profit margin. The cost of production will increase as the cost of energy rises. In this formula it can be recognized that processing cost is related as:

$25.11 per gallon * $0.00199 per gallon = $0.05/gal

This relation is due to the cost of energy at the point of production such that the energy cost of production is proportionally related to the current cost of crude oil prices. Using this same formula with the current price of crude oil it can be noted that:

$105.48 per gallon * $0.00199 per gallon = $0.20

Transporting diesel to the consumer is a process that is also relatable to the same structure of proportional price increase. The price of transportation is directly related to the wholesale cost of the diesel since the transportation requires diesel to power the different methods of transport. The proportional cost of transport can be represented according to Shumaker as:

$25.11 per gallon * $0.000796 per gallon = $0.02

Given the rise in cost of transportation due to the increase in fuel prices the current transportation cost can be shown as:

105.48 per gallon * $0.000796 per gallon = $0.08

Maintaining the same profit margins it can be show that the full structure of the cost of wholesale diesel based on these assumptions are as follows.

Current Wholesale Diesel Price Structure

WDP = Crude Oil Price per Barrel / 42 gallons + Processing ($0.20/gal) + Transportation ($0.08) + Profit ($0.05)

WDP = $105.48 (March 9, 2011) /42 + $.33 = $2.84 per gallon

The current pricing structure of bio-diesel can be calculated similarly as most assumptions and variables are the same. As stated above the most profitable production cost at 15 million gallons per year margin is $2.27 per gallon including processing. Using this method it incorporates the cost of processing in the peanut based diesel production per gallon.

The availability of creating a localized market would cut the need of transport of the peanut based bio-diesel by significant amount. The goal would be to cut the cost of transport by 50% from that of current transportation cost of diesel. This could be done with the aforementioned processes that will reduce cost and minimize transport distances, thus cutting transportation cost. This process can be shown as follows:

Wholesale Peanut based Bio-diesel Price Structure

WBDP = Peanut Based Diesel Production per gallon ($2.168) + Transportation ($0.10) + Profit ($0.05: Based on similar profit to Petroleum-diesel)

WBDP = $2.168+ $.15 = $2.32 per gallon

After transportation and profit the final cost of Wholesale Petroleum Based Diesel comes to $2.84 per gallon and the Wholesale Peanut Based bio-diesel Production cost amounts to $2.27 per gallon. With the addition of the $0.05 profit margin the final cost for wholesale peanut based bio-diesel to $2.32 per gallon. This $0.52 differential per gallon could annually save each consumer around 20% per year and more importantly offer a more sustainable process of energy consumption and production. One of the most important unseen benefits of this process compared to petroleum based fuels is that this price is mostly constant due to its renewable state. Petroleum sources are depleting and creating less supply driving the demand upward. The renewable infrastructure of bio-diesel offers relatively constant price point since the materials associated with productions can be restored.

6.5.1 Calorific value

The calorific value is the measurement of the amount of energy contained in the gas, this can be used to calculate and compare bio-diesels efficiency against other fuels. Analyzing the calorific value of bio-diesel per gallon and computing the amount of bio-diesel it requires to equal the current source of fuel per gallon will be used to calculate demand verses gasoline and diesel. This analysis will contribute to the total cost comparison of bio-diesel to current fuel sources used in Georgia and even the United States.

The most current analysis of the calorific value of biodiesel is 37,270 kJ / kg (Ibeto, 2011). This is slightly less than the value of petroleum diesel. Diesel's calorific value is 44,800 kJ / kg (Engineer Toolbox, 2010); the comparison of the two will output the amount of bio-diesel work per gallon compared to diesel. This analysis is depicted in the equation below:

$$(\textit{Bio-diesel})\ 37{,}270\ \text{kJ/kg} \,/\, (\textit{Diesel})\ 44800\ \text{kJ/kg} =$$

$$83.19\%\ \text{work per gallon compared to diesel}$$

This analysis can also be reversed to show the amount of bio-diesel per gallon is required to do the same amount of work as diesel. This analysis is depicted in the equation below:

(*Diesel*) 44800 kJ/kg / (*Bio-diesel*) 37,270 kJ/kg =

120.20% bio-diesel per gallon is required to do the same amount of work as diesel

From the above analysis it can be concluded that 120% biodiesel = 100% diesel and Biodiesel does 83.1919 % of the work diesel does per gallon.

As stated above the calorific value of biodiesel is 37,270 kJ / kg (Ibeto, 2011). This is slightly less than the value of gasoline. Gasoline's calorific value is 47,300 kJ / kg (Engineer Toolbox, 2010), the comparison of the two will output the amount of bio-diesel work per gallon compared to gasoline just as it did for diesel above. This analysis is depicted in the equation below:

(*Bio-diesel*) 37,270 kJ/kg / (*Gasoline*) 47,300 kJ/kg =

78.79% work per gallon compared to gasoline

This analysis can also be reversed to show the amount of bio-diesel per gallon is required to do the same amount of work as gasoline just as above. This analysis is depicted in the equation below:

(*Gasoline*) 47,300 kJ/kg / (*Bio-diesel*) 37,270 kJ/kg =

126.91 % bio-diesel per gallon is required to do the same amount of work as gasoline

From the above analysis it can be concluded that 126% biodiesel = 100% diesel and Biodiesel does 78.7949 % of the work diesel does per gallon. These observations will need to be applied to the total cost of bio-diesel production to properly compare market value of bio-diesel verses petroleum diesel and gasoline.

Referring above the market value of wholesale diesel is $2.84 per gallon and the calculated wholesale price for bio-diesel using the processes involved with this paper is 2.32 per gallon. To calculate the true market value in appreciation to the consumer, it would be necessary to evaluate the total cost of bio-diesel to equal the total cost of diesel in relation to the equal calorific value. This can be done by multiplying the price of bio-diesel by the bio-diesel per gallon is required to do the same amount of work as diesel calculated above.

$$\$2.32 \text{ per gallon} * 1.2020 \text{ gallons} = \$2.7886$$

Once this is done it shows the cost of bio-diesel to equal the same amount of energy output as diesel. It can be noted that this analysis adds $0.47 per gallon to the total cost of bio-diesel. With this addition it brings the total cost of bio-diesel to $2.79 in relation to diesel. Implying the $0.47 per gallon addition bio-diesel price equals the same price as diesel per gallon in relation to calorific output of $2.79.

The same analysis will need to be done for gasoline compared to bio-diesel to evaluate gasoline's market value compared to bio-diesel. Similarly this can be done by multiplying the price of bio-diesel by the bio-diesel per gallon is required to do the same amount of work as gasoline calculated above.

$$\$2.32 \text{ per gallon} * 1.26 \text{ gallons} = \$2.92$$

This shows the cost of bio-diesel to equal the same amount of energy output as gasoline. It can be noted that this analysis adds $0.60 per gallon to the total cost of bio-diesel. With this addition it brings the total cost of bio-diesel to $2.92 in relation to gasoline. The wholesale market value of gasoline as of March 22, 2011 is $3.00 per gallon (EIA, 2011). This analytical evaluation shows that bio-diesel is $0.08 cheaper per gallon in association with the calorific output of each. It is important to note that this analysis does not change the price of bio-diesel per gallon but just accounts for the necessary addition of fuel needed to do the same amount of work. The price of bio-diesel per gallon will remain $2.32 per gallon.

6.5.2 Biodiesel Demand and Cost

The demand of bio-diesel and feedstock required for total integration of will need to be calculated to determine the supply needed for this process. To calculate this demand, the total current fuel consumptions will need to be analyzed to determine current demand values. The fuel consumption of each state is presented below:

Table 13: Fuel demand in the United States classified according to State in billions of gallons.

Fuel Consumption by State (Billions of gallons)				
	State	Gasoline	Diesel	Total
AL	Alabama	2.58	0.77	3.36
AK	Alaska	0.29	0.24	0.53
AZ	Arizona	2.72	0.82	3.54
AR	Arkansas	1.43	0.63	2.06
CA	California	15.05	2.96	18.01
CO	Colorado	2.10	0.58	2.68
CT	Connecticut	1.49	0.30	1.79
DE	Delaware	0.45	0.07	0.51
DC	Dist. of Col.	0.12	0.03	0.14
FL	Florida	8.26	1.50	9.76
GA	Georgia	4.77	1.34	6.10
HI	Hawaii	0.45	0.06	0.51
ID	Idaho	0.66	0.25	0.91
IL	Illinois	4.90	1.48	6.37
IN	Indiana	3.10	1.32	4.41
IA	Iowa	1.62	0.65	2.28
KS	Kansas	1.31	0.48	1.79
KY	Kentucky	2.14	0.82	2.97
LA	Louisiana	2.16	0.70	2.86
ME	Maine	0.69	0.19	0.89
MD	Maryland	2.80	0.54	3.33
MA	Massachusetts	2.81	0.38	3.19
MI	Michigan	4.60	0.84	5.44
MN	Minnesota	2.63	0.67	3.29
MS	Mississippi	1.65	0.63	2.27
MO	Missouri	3.21	1.00	4.21
MT	Montana	0.48	0.25	0.74
NE	Nebraska	0.84	0.41	1.25
NV	Nevada	1.13	0.34	1.47
NH	New Hampshire	0.72	0.10	0.82
NJ	New Jersey	4.28	0.90	5.19
NM	New Mexico	0.93	0.47	1.40
NY	New York	5.63	1.42	7.06
NC	North Carolina	4.77	1.02	5.79
ND	North Dakota	0.36	0.20	0.56
OH	Ohio	5.08	1.51	6.59

Fuel Consumption by State (Billions of gallons)				
	State	Gasoline	Diesel	Total
OK	Oklahoma	1.84	0.91	2.75
OR	Oregon	1.51	0.54	2.05
PA	Pennsylvania	5.01	1.42	6.43
RI	Rhode Island	0.41	0.06	0.47
SC	South Carolina	2.58	0.68	3.26
SD	South Dakota	0.42	0.21	0.63
TN	Tennessee	3.07	1.00	4.08
TX	Texas	11.92	4.24	16.16
UT	Utah	1.06	0.46	1.52
VT	Vermont	0.33	0.06	0.39
VA	Virginia	3.96	1.04	4.99
WA	Washington	2.67	0.66	3.33
WV	West Virginia	0.77	0.29	1.05
WI	Wisconsin	2.51	0.75	3.26
WY	Wyoming	0.35	0.39	0.74
TOT	Total	136.61	38.56	175.17

Source: United States Department of Transportation [USDOT, 2010]

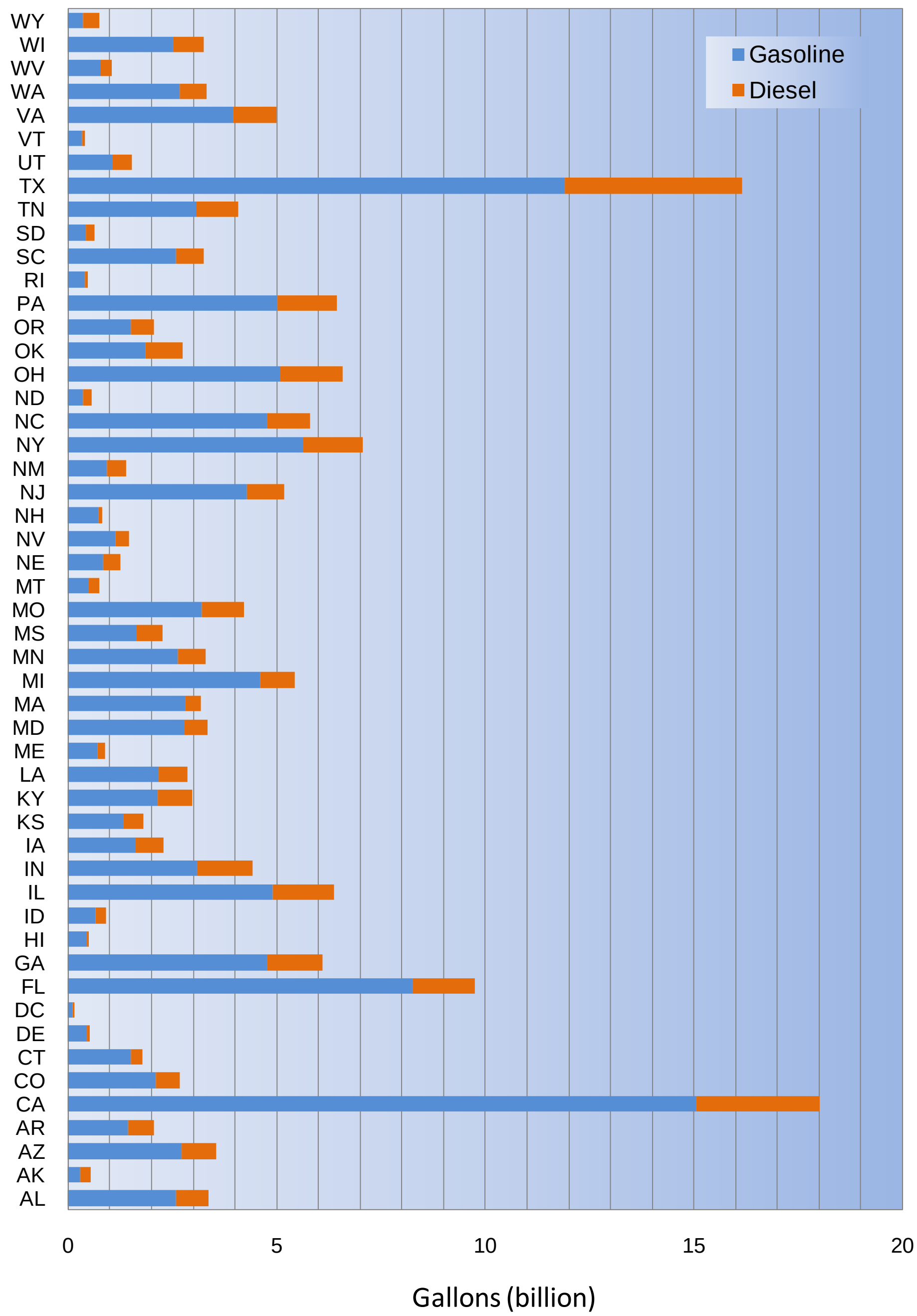

Figure 13: Classification of fuel demand based on type of fuel in different states

Source: United States Department of Transportation [USDOT, 2010]

From the table above it can be noted that the fuel consumption of Georgia is 6,100,000,000 gallons divided among gasoline at 4,770,000,000 gallons per year and diesel with 1,340,000,000 gallons per year. In order to calculate true demand the value of bio-diesel per gallon that is required to do the same amount of work as diesel as gasoline must be included in the demand equation. This can be shown below:

NOTE:

Diesel = 1.20 Bio-diesel / Gallon

Gasoline = 1.26 Bio-diesel / Gallon

Bio-diesel demand per year Georgia

- 1,340,000,000 gallons of diesel fuel * 1.20 (Calorific difference) = 1,608,000,000 gallons of bio-diesel
- 4,770,000,000 gallons of gasoline fuel * 1.26 (Calorific difference) = 6,010,200,000 gallons of bio-diesel
- 1,608,000,000 gallons of bio-diesel + 6,010,200,000 gallons of bio-diesel = 7,618,200,000 gallons required to supply total fuel demand for the state of Georgia

Bio-diesel demand per year United States

- 38,560,000,000 gallons of diesel fuel * 1.20 (Calorific difference) = 46,272,000,000 gallons of bio-diesel
- 136,610,000,000 gallons of gasoline fuel *1.26 (Calorific difference) = 172,128,600,000 gallons of bio-diesel
- 46,272,000,000 gallons of bio-diesel + 172,128,600,000 gallons of bio-diesel = 218,400,600,000 gallons required to supply total fuel demand for the United States

From this analysis it can be noted that the demand of bio-diesel required to completely satisfy the supply of fuel for the state of Georgia would equal 7,618,200,000 gallons per year. However this is under the unlikely assumption that conversion would be seamless and instant. It can be further interpreted to analyze trends of smaller scale integration methods given future acceptance and investments in bio-diesel.

Once bio-diesel demand is determined it is then possible to determine the demand of feedstock required to supply the manufacturer so that production levels can meet the demand of bio-diesel. Referring to Table 9 it takes 7.5 amounts of feed stock to make 1 galloon of biodiesel. This will be included with the above demand analysis to find the total feedstock demand.

NOTE:

One gallon = 7.5 lbs of feed stock

Diesel = 1.20 Bio-diesel / Gallon

Gasoline = 1.26 Bio-diesel / Gallon

Feedstock required per year Georgia

- 1,340,000,000 gallons of diesel fuel * 7.5 lbs of feed stock * 1.20 (Calorific difference) = 12,060,000,000 lbs of feed stock demand required to replace GA diesel supply
- 4,770,000,000 gallons of gasoline fuel * 7.5 lbs of feed stock * 1.26 (Calorific difference) = 45,076,500,000 lbs of feed stock demand required to replace GA gasoline supply
- 12,060,000,000 lbs of feed stock required to replace GA fuel supply + 45,076,500,000 lbs of feed stock required to replace GA gasoline supply = 57,136,500,000 lbs of feed stock demand required to replace GA total fuel supply

Feedstock required per year United States

- 38,560,000,000 gallons of diesel fuel *7.5 lbs of feed stock * 1.20 (Calorific difference) = 347,040,000,000 lbs of feed stock demand required to replace US diesel supply
- 136,610,000,000 gallons of gasoline fuel *7.5 lbs of feed stock *1.26 (Calorific difference) = 1,290,964,500,000 lbs of feed stock demand required to replace US gasoline supply
- 1,290,964,500,000 lbs of feed stock demand required to replace US gasoline supply + 347,040,000,000 lbs of feed stock demand required to replace US diesel supply = 1,638,004,500,000 lbs of feed stock demand required to replace US total fuel supply

Once the demand can be recognized it is then possible to predict growth, operating cost and other various engineering based economic analysis to determine violability of the plants processes and growth. The growth of demand can be presented to foreshadow different rates of growth in demand such that an analysis can be made to adjust supply levels at a profitable margin to account for such growth. This process will need to take the current rates of bio-diesel and its competing fuels to determine its demand based on consumption of each. Also the analysis of the feedstock's source associated with the bio-diesel will need to be accessed, in this case peanut. Depicted below is the current growth demand table showing demand growth by 5, 10, and 15 percent of current levels in gallons.

Table 14: Growth of Demand by percent for Gasoline, Diesel, Bio-diesel, and Feedstock Requirements for the State of Georgia in Gallons

Growth of Demand by Percent				
	Current	5%	10%	20%
Gasoline	4.77 Billion	5.01 Billion	5.24 Billion	5.72 Billion
Diesel	1.34 Billion	1.40 Billion	1.47 Billion	1.60 Billion
Bio-diesel	7.61 Billion	7.99 Billion	8.38 Billion	9.14 Billion
Feedstock (lbs)	57.13 Billion	59.99 Billion	62.85 Billion	68.56 Billion

Once the growth demand is recognized it can then be possible to simulate output capacity to determine installed cost. The two depictions below show the installed cost of various output capacities compared to different levels of free fatty acid rates.

Table 15: Bio-diesel Plant Budget Installed cost

Biodiesel Plant Budget Installed Cost			
Output Capacity	Low FFA	10% FFA	30% FFA
10,000,000	9,000,000	11,000,000	12,500,000
20,000,000	14,000,000	17,000,000	19,000,000
30,000,000	17,000,000	21,500,000	24,000,000

Source: [Van Gerpen, 2008]

As stated earlier the most profitable output capacity is 15 million gallons per year. Referring to Figure 14, it can be recognized that the 10% free fatty acid installed cost at 15 million gallons annually amounts to 16.5 million dollars.

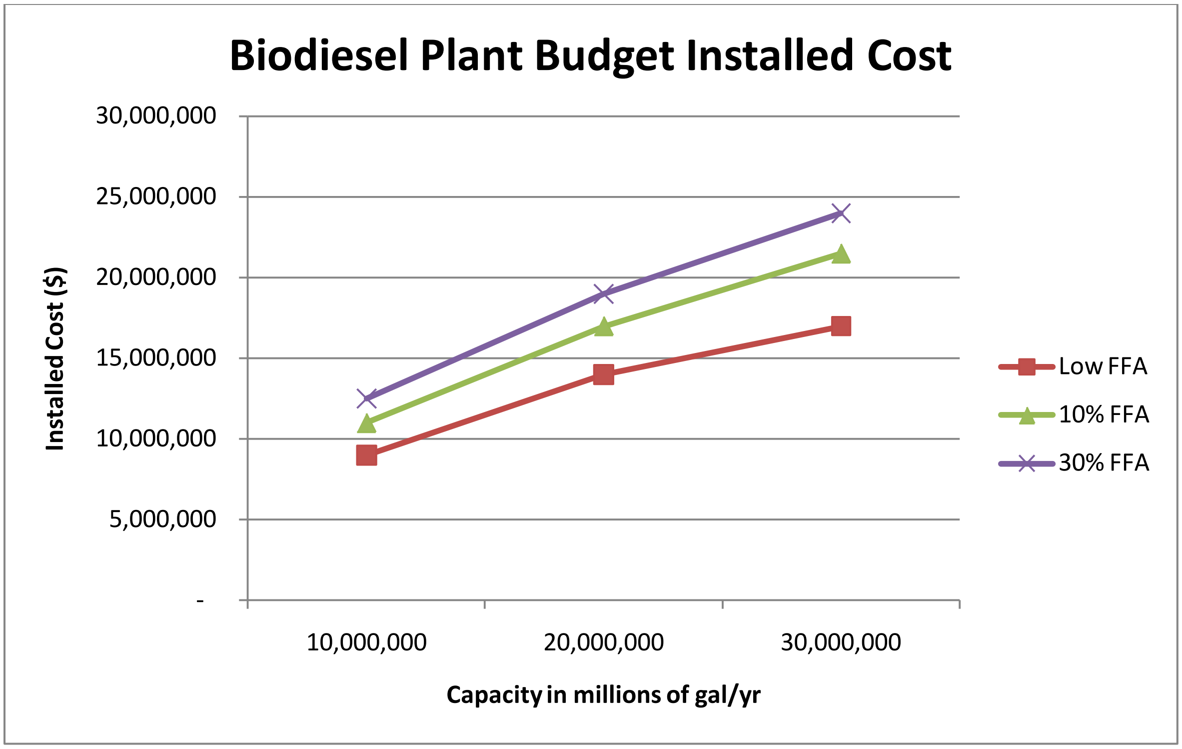

Figure 14: Bio-diesel Plant Budget Installed cost

Source: [Van Gerpen, 2008]

By analyzing the operating cost of a 15 million gallon per year bio-diesel production plant using peanuts as a source, the localized cost of using the above process will become apparent. This analysis must be very detailed and incorporate all factors that contribute to operation cost. Failure to incorporate contributions to operation cost can create unreliable and incorrect results. Also the cost and quantity of these factors will need to be up to date and accurate given their imperative correlation to the final cost of production. It is also important to incorporate human labor, depreciation, and subtraction of sales of byproducts left over from the production processes. This analysis is depicted in Table 15.

Table 16: Operating Cost of a 15 Million Gallon per Year Bio-diesel Plant Using Peanuts

Raw Material	**Price/Unit $**	**Unit per gallon of Diesel**	**Units/year**	**Cost/Year ($)**	**Cost per gallon of Diesel**
Peanut Oil (lbs)	$ 0.2500	7.5000	112,500,000.0000	$28,125,000.00	$ 1.8750
Transportation (rail Cars)	$ 3,000.0000		500.0000	$ 1,500,000.00	$ 0.1000
Methanol (gal)	$ 1.2800	0.1400	2,100,000.0000	$ 2,688,000.00	$ 0.1792
Catalyst (lb.)	$ 1.9600	0.0800	1,200,000.0000	$ 2,352,000.00	$ 0.1568
Utilities					
Electricity (Kilowatt hours)	$ 0.0690	0.0030	1,200,000.0000	$ 82,800.00	$ 0.0083
Natural gas/diesel (decatherms)	$ 7.0000	0.0077	115,500.00	$ 808,500.00	$ 0.0809
Water	$ 0.0030	0.3822	5,733,000.00	$ 17,199.00	$ 0.0017
Labor					
Manager/Operator	$ 65,000.0000		1.00	$ 65,000.00	$ 0.0043
Operator	$ 40,000.0000		6.00	$ 240,000.00	$ 0.0160
Lab technician	$ 35,000.0000		1.00	$ 35,000.00	$ 0.0023
Maintenance	$ 30,000.0000		2.00	$ 60,000.00	$ 0.0040
Sales	$ 35,500.0000		1.00	$ 35,500.00	$ 0.0024
Support Staff	$ 18,000.0000		1.00	$ 18,000.00	$ 0.0012
Benefits @32%				$ 145,120.00	$ 0.0145
Misc					
Maintenance				$ 150,000.00	$ 0.0100
Insurance				$ 375,000.00	$ 0.0250
Marketing				$ 150,000.00	$ 0.0100
Permits				$ 45,000.00	$ 0.0030
Waste Disposal (tons)	$ 35.0000		600.00	$ 21,000.00	$ 0.0014
Waste Water Treatment	$ 0.0110		2,000,000.00	$ 22,000.00	$ 0.0015
Depreciation					

Raw Material	Price/Unit $	Unit per gallon of Diesel	Units/year	Cost/Year ($)	Cost per gallon of Diesel
Building				$ 24,750.00	$ 0.0017
Equipment				$ 571,600.00	$ 0.0381
Storage Tanks				$ 45,728.00	$ 0.0030
Sale of Byproducts					
Glycerin (lb.)	$ 0.0500		9,750,000.00	$ (487,500.00)	$ (0.0325)
Soap Stock (lb.)	$ 0.0100		6,000,000.00	$ (60,000.00)	$ (0.0040)
Total				$37,029,697.00	$ 2.5038

From this analysis it can be recognized that a 15 million gallon per year bio-diesel production facility would have an annual cost of $37,497,097 and a production cost of $2.50 per gallon. It must also be recognized that this analysis does not account for potential measures to increase sustainability within the manufacturing process. The excess glycerol from the process can be reprocessed for electricity by adding a convection oven to the installed cost presented in Table 11 which can be easily paid off by the recurring benefit of a sustainable source of energy. The small lose of sales of glycerol will also be consumed by the recurring benefit of the sustainable energy production process. It can also be noted that waste from peanut shells will decrease but will not have nearly any significant effect on the cost waste disposal. The cost of marketing is less than 0.5% of total cost which is considered low for a product with such small market share but given its unique market situation this price is fairly adequate.

Table 17: Operating Cost of a 15 Million Gallon per Year Bio-diesel Plant Using Peanuts and sustainability measures to reduce cost

Raw Material	**Price/Unit $**	**Unit per gallon of Diesel**	**Units/year**	**Cost/Year ($)**	**Cost per gallon of Diesel**
Peanut Oil (lbs)	$0.2500	7.5000	112,500,000.0000	$28,125,000.00	1.8750
Transportation (rail Cars)	$3,000.0000		500.0000	$ 1,500,000.00	$0.1000
Methanol (gal)	$1.2800	0.1400	2,100,000.0000	$2,688,000.00	$0.1792
Catalyst (lb.)	$1.9600	0.0800	1,200,000.0000	$ 2,352,000.00	$0.1568
Utilities					
~~Electricity (Kilowatt hours)~~	~~$0.0690~~	~~0.0030~~	~~1,200,000.0000~~	~~$82,800.00~~	~~$0.0083~~
Natural gas/diesel (decatherms)	$7.0000	0.0077	115,500.00	$808,500.00	$0.0809
Water	$0.0030	0.3822	5,733,000.00	$17,199.00	$0.0017
Labor					
Manager/Operator	$65,000.0000		1.00	$65,000.00	$0.0043
Operator	$40,000.0000		6.00	$240,000.00	$0.0160
Lab technician	$35,000.0000		1.00	$35,000.00	$0.0023
Maintenance	$30,000.0000		2.00	$60,000.00	$0.0040
Sales	$35,500.0000		1.00	$35,500.00	$0.0024
Support Staff	$18,000.0000		1.00	$ 18,000.00	$ 0.0012
Benefits @32%				$ 145,120.00	$ 0.0145
Misc					
Maintenance				$ 150,000.00	$ 0.0100
Insurance				$ 375,000.00	$ 0.0250
Marketing				$ 150,000.00	$ 0.0100
Permits				$ 45,000.00	$ 0.0030
Waste Disposal (tons)	$35.0000		600.00	$ 21,000.00	$ 0.0014

Raw Material	Price/Unit $	Unit per gallon of Diesel	Units/year	Cost/Year ($)	Cost per gallon of Diesel
Waste Water Treatment	$0.0110		2,000,000.00	$ 22,000.00	$ 0.0015
Depreciation					
Building				$ 24,750.00	$ 0.0017
Equipment				$ 571,600.00	$ 0.0381
Storage Tanks				$ 45,728.00	$ 0.0030
Sale of Byproducts					
~~Glycerin (lb.)~~	~~$0.0500~~		~~9,750,000.00~~	~~$ (487,500.00)~~	~~$ (0.0325)~~
Soap Stock (lb.)	$0.0100		6,000,000.00	$ (60,000.00)	$ (0.0040)
Total				$ 37,434,397.00	**$ 2.5280**

6.5.3 Economics Analysis of Bio-diesel Production

The following analysis is used to determine the level of profit if any by comparing the financial benefits with the operation cost. This is done using the 30 year Treasury rate where interest equals 4.5%, it can be noted that the rate is subject to market fluctuations. If the plant was to be started at this moment the full analysis reflects related cash flows. Assuming a standard plant life of 15 years, as mentioned the cost per gallon of biodiesel remains $2.27 with a capacity of 15 million gallons production per year as stated above. The annual cost of operation will be calculated by multiplying the price per gallon of bio-diesel by the amount of gallons production annually. The installed cost will be adapted from Table 11, and the annual revenue will be calculated by the selling price multiplied by the amount of gallons production annually. This selling price will refer to the current average market price of bio-diesel. This analysis will take place over 15 years, and also assuming a uniform demand with no salvage value at the end of the life of the plant.

- Annual cost (A) = $2.53 per gallon* 15,000,000 gallons
- Recurring Revenue per year = $3.08 per gallon * 15,000,000 gallons
- Time = 0-15 years
- Installed Cost = $10,603,000

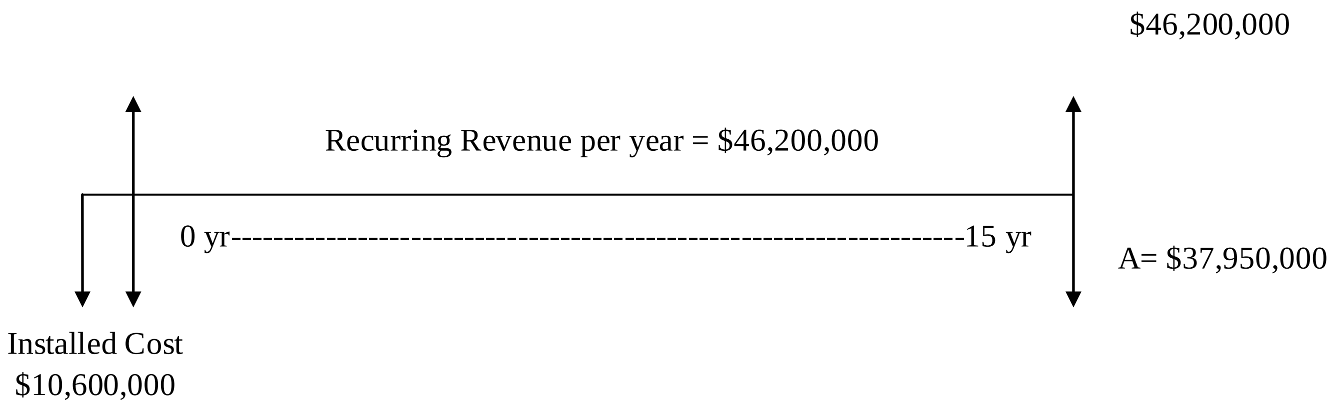

Figure 15: Benefit Cost Analysis of Bio-diesel Production (Assuming $0.00 salvage cost)

Benefit/Cost Analysis with No Salvage Value

Referring to the given information above, the benefit analysis can be calculated using the following formula:

Note: P/A can be obtained in Table 18.

PW (Cost) = Installed Cost + Recurring Cost per Year (P/A, í, n)
PW (Cost) = Installed Cost (10,600,000) + Recurring Cost per Year (37,950,000) * (10.7395)
PW (Cost) = 418,164,025

PW (Benefit) = $ 46,200,000 (P/A, í, n)
PW (Benefit) = $ 46,200,000 * (10.7395)
PW (Benefit) = $ 496,164,900

Benefits/Cost= $496,164,900/$418,164,025=1.1865→ (highly profitable)

It can be noted that as long as PW of benefits is greater than $418,164,025 the situation is profitable, if equal then break even, if less then loss.

418,164,025/10.7395 = (breakeven revenue)

To calculate the breakeven price that determines profit or loss the breakeven revenue shown above will be divided by the gallons produced per year.

(Breakeven price per gallon) = (Breakeven revenue) / $15,000,000 (Gallon produced per year)

The breakeven price of bio-diesel based on the above analysis is $2.59

Benefit/Cost Analysis with 10% Salvage Value

The following analysis is similar to the one above but it incorporates as end of useful life 10% salvage value of equipment and buildings. To do this the salvage value will need to calculate by adding up the cost of the factor in the installed cost that has active depreciation on annual basis:

- Annual cost (A) = $2.53 per gallon * 15,000,000 gallons
- Recurring Revenue per year = $3.08 per gallon * 15,000,000 gallons
- Time = 0-15 years
- Installed Cost = $10,600,000
- Equipment Cost= $4,600,000
- Building Cost = $1,200,000
- Total =$5,800,000
- Salvage value = 10% of $ 5,800,000
- Salvage value =$580,000

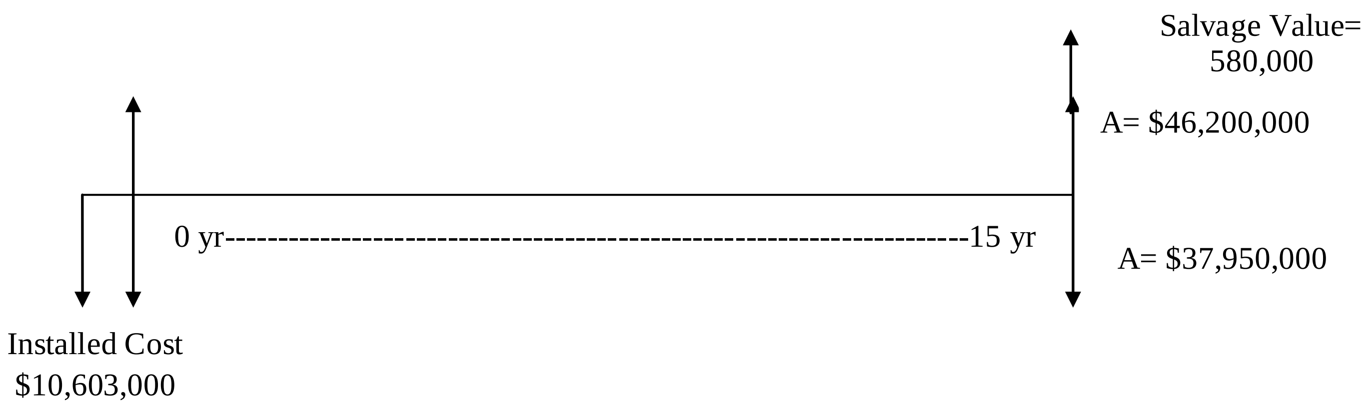

Figure 16: Benefit Cost Analysis of Bio-diesel Production (Assuming 10% salvage cost)

PW (Cost) = $ 418,164,025

PW (Benefit) = $ 46,200,000 + Salvage Value ($ 580,000)* (P/F, í, n)
= $ 46,200,000 * 10.7395 + $ 580,000 * (0.5167)
= $ 496,164,900 + $ 299,686
PW (Benefit) = $ 496,464,586

Benefits/Cost=$ 496,464,586/ $ 418,164,025=1.1872 → (Highly profitable)

The results of this benefit cost analysis show that even with a 10% salvage value the cost using the above processes is highly profitable and cost efficient. This offers profitable opportunities to increase the overall acceptance and viability of the product as bio-diesel integration

Table 18: Compound Interest Factors

4.50%								4.50%
n	F/P	P/F	A/F	A/P	F/A	P/A	A/G	P/G
1	1.0450	0.9569	1.0000	1.0450	1.0000	0.9569	0.0000	0.0000
2	1.0920	0.9157	0.4890	0.5340	2.0450	1.8727	0.4890	0.9157
3	1.1412	0.8763	0.3188	0.3638	3.1370	2.7490	0.9707	2.6683
4	1.1925	0.8386	0.2337	0.2787	4.2782	3.5875	1.4450	5.1840
5	1.2462	0.8025	0.1828	0.2278	5.4707	4.3900	1.9120	8.3938
6	1.3023	0.7679	0.1489	0.1939	6.7169	5.1579	2.3718	12.2333
7	1.3609	0.7348	0.1247	0.1697	8.0192	5.8927	2.8242	16.6423
8	1.4221	0.7032	0.1066	0.1516	9.3800	6.5959	3.2694	21.5646
9	1.4861	0.6729	0.0926	0.1376	10.8021	7.2688	3.7073	26.9478
10	1.5530	0.6439	0.0814	0.1264	12.2882	7.9127	4.1380	32.7431
11	1.6229	0.6162	0.0722	0.1172	13.8412	8.5289	4.5616	38.9051
12	1.6959	0.5897	0.0647	0.1097	15.4640	9.1186	4.9779	45.3914
13	1.7722	0.5643	0.0583	0.1033	17.1599	9.6829	5.3871	52.1627
14	1.8519	0.5400	0.0528	0.0978	18.9321	10.2228	5.7892	59.1823
15	1.9353	0.5167	0.0481	0.0931	20.7841	10.7395	6.1843	66.4164
16	2.0224	0.4945	0.0440	0.0890	22.7193	11.2340	6.5723	73.8335
17	2.1134	0.4732	0.0404	0.0854	24.7417	11.7072	6.9534	81.4043
18	2.2085	0.4528	0.0372	0.0822	26.8551	12.1600	7.3275	89.1019
19	2.3079	0.4333	0.0344	0.0794	29.0636	12.5933	7.6947	96.9013
20	2.4117	0.4146	0.0319	0.0769	31.3714	13.0079	8.0550	104.7795
21	2.5202	0.3968	0.0296	0.0746	33.7831	13.4047	8.4086	112.7153
22	2.6337	0.3797	0.0275	0.0725	36.3034	13.7844	8.7555	120.6890
23	2.7522	0.3634	0.0257	0.0707	38.9370	14.1478	9.0956	128.6827
24	2.8760	0.3477	0.0240	0.0690	41.6892	14.4955	9.4291	136.6799
25	3.0054	0.3327	0.0224	0.0674	44.5652	14.8282	9.7561	144.6654
26	3.1407	0.3184	0.0210	0.0660	47.5706	15.1466	10.0765	152.6255
27	3.2820	0.3047	0.0197	0.0647	50.7113	15.4513	10.3905	160.5475
28	3.4297	0.2916	0.0185	0.0635	53.9933	15.7429	10.6982	168.4199
29	3.5840	0.2790	0.0174	0.0624	57.4230	16.0219	10.9995	176.2323
30	3.7453	0.2670	0.0164	0.0614	61.0071	16.2889	11.2945	183.9753
31	3.9139	0.2555	0.0154	0.0604	64.7524	16.5444	11.5834	191.6404
32	4.0900	0.2445	0.0146	0.0596	68.6662	16.7889	11.8662	199.2199
33	4.2740	0.2340	0.0137	0.0587	72.7562	17.0229	12.1429	206.7069
34	4.4664	0.2239	0.0130	0.0580	77.0303	17.2468	12.4137	214.0955
35	4.6673	0.2143	0.0123	0.0573	81.4966	17.4610	12.6785	221.3802
40	5.8164	0.1719	0.0093	0.0543	107.0303	18.4016	13.9172	256.0986
45	7.2482	0.1380	0.0072	0.0522	138.8500	19.1563	15.0202	287.7322
50	9.0326	0.1107	0.0056	0.0506	178.5030	19.7620	15.9976	316.1450

CHAPTER 7

CONCLUSION

7.1 Direction for Future Research

At the completion of this paper there are various levels of interest yet to be explored that can benefit the increased integration of bio-diesels.

1. The chemical and biological properties involving bio-diesel composition can be further investigated to create a more efficient or environmentally conscious exchange. These processes could also cut cost in initial composition which would in turn cut final cost.
2. The logistics of making bio-diesel more readily available to the consumer could create a smoother transition for consumers and retailers. The in-depth consideration of these logistics could be used to develop a method to cut cost and increase resistance to change.
3. Also the large scale logistic methodology of utilizing local resources to cut transportation of goods would increase viability and offer lower overall cost of production.
4. Further exploration of utilization of by-products involved with the entire production process could increase total profit and make pricing even more feasible.
5. Increased examination of the properties and outputs of bio-diesel mixing could offer large scale advantages including price reduction and consumer acceptance due to ease of transition from each product.

6. Lastly an entire system analysis of the top to bottom process involved with the production and logistics of each system as they relate to one another to make the most efficient production process possible and maximize efficiency while cutting cost.

7.2 Summary Project

This thesis presented key concepts related to the composition, cost benefits, environmental effects, and emission composition of peanut based bio-diesel in the region of South Georgia. Given the geopolitical uncertainty, it is crucial to develop an alternate energy source in order to replace fossil fuels. Biodiesel could serve as one such alternative. The benefits of bio-diesel vis-à-vis fossil fuels were presented in this paper. However in spite of documented benefits, mainstream integration of biodiesel remains elusive. This can be attributed to the lack of a comprehensive development effort and methodology to enable widespread availability as well as acceptance. Integration of clean energies would require new production facilities and new methods of extraction and refining. The strategic utilization and process development of these issues could offer solutions to the barriers of increased or even total conversion to bio-diesel as a dominant energy source.

Following the research and strategic analysis involved with integrating peanut based bio-diesel it is possible to conclude that feasibility is definitely reasonable and achievable. The processes invested in this paper explain efficient and profitable methods to initiate the integration process with in the market range of South Georgia. The existence of a reduced cost per gallon process of integrating a sustainable energy offers tremendous opportunities to stimulate our economy and advance our way of life, while preserving our environment. This research is easily expandable to analyze the larger expansion. It can also be noted that this process is more exultant as the expansion grows and consumer investment increases. As consumer investment and commitment increases conversion will also become more profitable creating even more opportunities for growth. Renewable technologies are an investment that opens possibilities for exponential growth that expands throughout the renewable market and all others associated with its processes. The implementing of these processes are inevitable as current resources deplete it only become more and more costly to delay the advancement of renewable and sustainable technologies.

REFERENCES

[1] Arvizu, D. (2007). Biofuels research and development to reduce reliance on imported petroleum. *National Renewable Energy Laboratory*, 1-7.

[2] Van Gerpen, J. (2004). Bio-diesel Production and Fuel Quality. (2004). Moscow, Idaho: University of Idaho

[3] Kammen, D. M., Kapadia, K., & Fripp, M. (2004). Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate? (2004). *Report of the renewable and appropriate energy laboratory*. Berkeley, California: University of California Berkeley.

[4] Ending the Energy Stalemate - A Bipartisan Strategy to Meet America's Energy Challenges. (2004). Washington, DC: National Commission on Energy Policy.

[5] Mosier, N., Welch, G., & Dien, B. (2003). Building a Bridge to the Ethanol Industry. (2003). Golden, Colorado: National Renewable Energy Laboratory.

[6] Foust, T.D. (2007). Examination of Alternative Transportation Fuels to Reduce Dependence on Foreign Oil. (2007). Washington, DC: National Renewable Energy Laboratory.

[7] Lindhjem, C. (2003). Impact of Bio-diesel Fuels on Air Quality and Human Health: Incorporate Bio-diesel Data into Vehicle Emissions Databases for Modeling. (2003). Washington, DC: National Renewable Energy Laboratory.

[8] Van Gerpen, J. (2004). Business Management for Bio-diesel Producers. (2004). Ames, Iowa: National Renewable Energy Laboratory.

[9] Van Gerpen, J., Clements, D., Knothe, G., Shanks, B., & Pruszko, R. (2004). Bio-diesel Production Technology. (2004). Golden Colorado: National Renewable Energy Laboratory.

[10] Van Gerpen, J. (2004). Business Management for Bio-diesel Producers. (2004). Golden Colorado: National Renewable Energy Laboratory.

[11] Lindhjem, C., & Pollack, A. (2003). Impact of Bio-diesel Fuels on Air Quality and Human Health: Task 1 Report Incorporate Bio-diesel Data into Vehicle Emissions Databases for Modeling. (2003). Novato, California: ENVIRON International Corporation.

[12] US Environmental Protection Agency, Initials. (2010). Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis. Retrieved (2010, July 9) from http://www.epa.gov/otaq/renewablefuels/420r10006.pdf

[13] Sourie, J., Treguer, D., & Rozakis, S. (2006). Economic impact of biofuel chains in France. (2006). Paris, France: INRA.

[14] Birur, D. K., Hertel, W., & Tyner, W.E. (2007). Impact of Biofuel Production on World Agricultural Markets: A Computable General Equilibrium Analysis. (2007). *GTAP working paper*. West Lafayette, Indiana: Department of Agricultural Economics, Purdue University.

[15] Tyson, K. (1997). Biodiesel Research Progress 1992-1997. (1997). Golden Colorado: National Renewable Energy Laboratory.

[16] Vasudevan, P., & Briggs, M. (2008). Biodiesel production—current state of the art and challenges. (2008). *J ind microbiol biotechnol*. Society for Industrial Microbiology.

[17] Harwood HJ. Oleochemicals as a fuel: mechanical and economic feasibility. JAOCS 1984;61:315–24.

[18] U.S. Economic Impact of Advanced Biofuels Production: Perspectives to 2030. (2009). Bio-era.

[19] Patel, M. K., & Gaya, J. C. (2003). Biodiesel from rapeseed oil and used frying oil in European Union. (2003). Copernicus Institute

[20] Renewable Energy Research Laboratory, University of Massachusetts at Amherst. (2008) Wind Power: Capacity factor, intermittency, and what happens when the wind does not blow.

[21] World Coal Institute. Internet link: www.worldcoal.org/coal/coal-mining

[22] Rhodes, D. (2009). native and natural born citizenship explored. *Global Temperature Trends*, Retrieved from http://thestateofamerica.wordpress.com/2008/01/22/foreign-oil-dependence-of-american-consumers-and-presidential-candidates/

[23] Downs, D. (2008). Foreign oil dependence of American consumers and presidential candidates. *The State of America Word press*, Retrieved from http://thestateofamerica.wordpress.com/2008/01/22/foreign-oil-dependence-of-american-consumers-and-presidential-candidates/

[24] Shumaker, G, Mckissick, J, Ferland, C, & Doherty, B. (2003). A Study on the Feasibility of Biodiesel Production in Georgia. *Center for agribusiness and economic development*. University of Georgia

[25] US Energy Information Administration. (2010). Crude Oil FAQ's and Statistics from http://www.eia.doe.gov:80/ask/crudeoil_faqs.asp

[26] Shumaker, G, Mckissick, J, Ferland, C, & Smith N. (2007). A Study on the Economics of Peanuts for Biodiesel Production. *Center for agribusiness and economic development*. University of Georgia

[27] Van Gerpen, J. (2010). *Commercial and large scale biodiesel production systems*. Manuscript submitted for publication, Department of Biological and Agricultural Engineering, , University of Idaho , Moscow, ID , Retrieved from http://www.extension.org/pages/Commercial_and_Large_Scale_Biodiesel_Production_Systems#Contributors_to_this_Article

[28] Frazier Barnes & Associates, (2005). Economic Feasibility of Producing Biodiesel in Tennessee. http://web.utk.edu/~aimag/pubs/biodiesel.pdf_University of Tennessee – Agri-Industry Modeling & Analysis Group, in cooperation with Frazier Barnes & Associates; date unknown.

[29] Grant, B. (2009, February 26). *Can Bio-fuels boost economy?* Retrieved from http://www.the-scientist.com/blog/display/55481/

[30] (n.d.). *Gas prices over the last 6 years*. Retrieved from http://gasbuddy.com/gb_retail_price_chart.aspx(n.d.).

[31] *National center for environmental protection*. (2010, November 03). Retrieved from http://www.ncep.noaa.gov/

[32] American GDP over the last 40 years. (2010). Retrieved October 8, 2010, from http://www.bea.gov/newsreleases/national/gdp/gdpnewsrelease.htm

[33] Addison, K. (2009). Bio-Emissions. Retrieved February 2, 2011, from journeytoforever.org/biodiesel.html

[34] National low-blend frequently asked questions. (2006). *National Biodiesel Board*,

[35] Van Gerpen, J. (2001). Biodiesel production from oils and fats with high free fatty acids. *Transaction of the ASAE*, *44*(6), 1429-1426.

[36] Engineer Toolbox, Initials. (2010). Calorific Values of Various Fuels. Retrieved March 28, 2011, from http://www.engineeringtoolbox.com/fuels-higher-calorific-values-d_169.html

[37] Ibeto, C.N., A.U. Ofoefule and H.C. Ezugwu, 2011. Analytical methods for quality assessment of biodiesel from animal and vegetable oils. Trends Applied Sci. Res., 6: 537-553.

[38] United States Department of Transportation, Federal Highway Administration, Office of Highway Policy Information, Highway Statistics. (2010). *Fuel consumption by state* Retrieved from http://www.fhwa.dot.gov/

[39] Van Gerpen, J. (2008). Bio-diesel Economics. (2008). Moscow, Idaho: University of Idaho

[40] Johnson, D., and K. Taconi. "The Glycerin Glut: Options for the Value-Added Conversion of Crude Glycerol Resulting from Biodiesel Production." *InterScience* 10.1002/ep.10225. (2007): 338-348. Web. 19 Apr 2011.

Project Proposal (09/2009)

As a first year graduate student I am proposing to research ways to help move laboratory based technologies to a mainstream market so we can begin utilizing the hard work of students and researchers. Bio-fuels have been around for such a long time and we are still damaging our environment, paying high gas prices, and stumbling over foreign policies, so we can use petroleum based fuels. With research I have established that there are three main obstacles in the way of increasing the production and demand of bio-diesel. The most important is the price and the willingness for the market to convert over to bio-diesel. As humans we have issues with changing the way we do things once they are already in our routine. So convincing a market to comply with and accept the change will be a large step to making bio-fuels more conventional. Economics is the second step to overcome. Fossil fuels are a large part of the global economy. America uses nearly 143 billion gallons of fuel a year and at over three dollars a gallon that is a large percent of our US economy. Without this multi-billion dollar industry the American economy would be devastated. The third reason is the production of bio-diesel is less advanced and defined. We have been producing petroleum based fuels for the last 100 years and we have become adequately efficient and productive in our methods. Developing a new fuel requires a different process that will need to be tested and refined.

Narrowing my research down to the production of bio-diesel and even further to peanut based bio-diesel, specifically in the geographic area of southern Georgia will make for more specific and relatable research. Continuing my research, by November 15th 2010 I plan to finish my literature review. I have been reading many different publications dealing with bio-diesel production, formulation, and economic responses. After the literature review is done and approved by all committee members I will start the actually research paper that will be submitted to different conferences and journals to be published and accepted by the professional community. Lastly in April 2011 I will defend my final research paper for the College of Graduate Studies.

My committee that I proposed includes Dr. Anoop Desai, committee chair and advisor. Dr. Desai will be responsible for helping me negotiate with organizations for conference participation and journal publication. Dr. Valentin Soloiu, who is the chair for the Renewable Energies Laboratory will be a great source of information and someone to look to for technical assistance. Dr. John O'Malley, a Professor in the Information Technology Department will be my outside advisor to help with my paper overview. Also I must mention although not a committee member Jeffery Lewis and Chari Mackey will be helping me obtain information and showing me production methods of peanut based bio-diesel given their unique experience on the given topic.